# THE TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW.

VOL. VIII.—No. 168.


## INAUGURAL ADDRESS.

By WILLIAM HENRY PREECE (President).

Delivered before the Society of Telegraph Engineers, Jan. 28, 1880.

ON surveying the wide sea upon which the numerous and varied practical applications of Electricity are launched for the subject of this evening's address, I have been puzzled to steer a course that shall avoid the dazzling shoals of theory on the one hand, and the dry, hard rocks of practice on the other. Hypothesis is a veritable Scylla that captivates the imagination and often sends the visionary to destruction, while practice alone is a hard-hearted Charybdis that lures the matter-of-fact practical man to folly and expense. Practice must be tempered with theory to utilise advantageously the great forces of nature, and theory itself must be based on practice, or on facts, to be comprehensive and acceptable. Hence success is the offspring of the marriage of practice and theory, and, therefore, as the two are so intimately connected, I have determined to steer a middle course to-night to survey the progress of each in our profession, and to show their mutual relationship.

What is theory? It is an explanation of the hidden cause of certain effects that are evident to the senses. It is an effort of the imagination to account for operations that are in themselves invisible and insensible, but which result in facts that are observable and known. Thus the movements of all those bright bodies by which

> "The floor of heaven
> Is thick inlaid with patines of bright gold,"

are explained by the theory of gravity. Their appearance, vagaries, and beauties are accounted for by the undulatory theory of light. The warmth that the monarch of them all shed upon this earth countless ages ago, and that is now restored to us in our household fires, is explicable on the molecular theory of heat. The constitution of matter and its various states of solid, liquid, and gas, are completely explained by the atomic theory of Democritus and Dalton, and the modern kinetic theory of gases.

It is impossible for a practical man who has devoted more than a quarter of a century to the application of electricity to useful purposes to avoid devoting much contemplation to the nature of the agent which he has to make use of. The imagination cannot be checked. The mind will dream and theorise. The untutored savage fancies he hears in the roar of the thunder the anger of the Great Spirit, and the tutored Greek saw in the daily course of the sun the chariot wheels of his god, Helios, and in the grey dawn of the morning the advent of the soft and gentle Aurora. The Saxon churl saw in the lambent flame of the phosphuretted hydrogen of his marshes the gambolings of Jack-o'-Lantern, or the treacherous ways of Will-o'-the-Wisp. Is there a member of this Society who has not striven to peer into the region of the unknown, who has not speculated on the power he uses, or who has not formed some conception in his mind of the nature of electricity? Yet it is remarkable that the answer to the question, What is electricity? cannot even now be given with authority. Faraday, our great apostle, whose researches should be every electrician's bible, declined to venture an answer, nor did he ever directly formulate his ideas on the subject, though his publications indicate pretty clearly and with no uncertain sound, what they were Clerk-Maxwell, who, while he overthrew all existing theories, failed to supply their place before he was so untimely removed from us. Sir William Thomson, in his published papers, always carefully eschews the consideration of any physical theory of electricity. The French electricians simply use the one-fluid theory as a convenience of language, while the Germans, as a rule, employ the two-fluid theory merely for mathematical purposes. Hence there is no recognised theory of electricity. Some maintain, with Du Fay or with Franklin, that it is a form of matter—a substance; others, following Faraday and Grove, consider it a form of force—a motion—like heat and light. It must be either one or the other. There is no other category in which to class it. If it is not a form of matter it must be a form of force. The question I propose to discuss is, therefore, Is electricity a form of matter, or is it a form of force?

In discussing such a vexed question it is necessary to be very precise in language to avoid any misconception of my meaning, therefore I will define both matter and force in the sense in which I use those terms. *Matter* is that which can be perceived by the senses, or can be acted upon by force. It is characterised by weight, inertia, and elasticity. *Force* is that which produces, or tends to produce, the motion of matter. It may be pressure, tension, attraction, repulsion, or anything capable of causing alteration in the natural state of rest or of existing motion of matter.

Matter consists of sixty-four known elements which have not yet been decomposed by any known means. There may be other elements that have not yet been discovered by chemists, but they must exist in some known compound. Matter is found in either the solid, liquid, gaseous, or ultra-gaseous state, and it occupies space. It consists of molecules and atoms. The *atom* is the smallest indivisible part of an element, and a group of atoms of the same or of different elements forms the *molecule*, which has a definite magnitude and is unalterable in form for each substance. The *mass* of a substance is the aggregate of the molecules of which it is composed. There is no generation or destruction of

atoms. The indestructibility of matter is a fixed law in nature. The size of the molecule is approximately known. Sir William Thomson says: "If we conceive a sphere of water as large as a pea to be magnified to the size of the earth, each molecule being magnified to the same extent, the magnified structure would be coarser-grained than a heap of small lead shot, but less coarse-grained than a heap of cricket balls." Fifty million molecules ranged in single file would occupy an inch. They are highly elastic, and unless interfered with would move with constant velocity in straight lines. When they can move about freely without interfering with each other's proceedings, we have the ultra-gaseous state of Crookes, a state found only in very high vacua and under certain adventitious circumstances. When they collide and impinge on each other according to the law of the impact of elastic bodies, interfering with each other's path, we have *gases* as we know them; when their mean free path is so reduced as to bring them within the sphere of mutual attraction, without too narrowly restricting their play, we have *liquids*; when the attraction becomes cohesion, and the motion of the molecule is confined to its own sphere, we have *solids*. The number of molecules in a given volume of gas is known, and their velocity calculated. In hydrogen the velocity at 0° Cent. is 6,097 feet per second, the number being $10^{23}$ per cubic inch. The mean free path of a molecule in air at ordinary pressures is the ten-thousandth part of a millimetre. Besides their constant motion in straight lines the molecules may be set in vibration, rotation, or any other kind of relative motion whatever.

This is the atomic theory of matter born in the brain of Democritus, "the laughing philosopher," 2,300 years ago; preached by Epicurus in Athens, and taught by Lucretius in Rome before the Christian era; lying dormant for eighteen centuries, until it was formulated by Dalton in the last century, and removed from the region of pure speculation by Joule, Clausius, Clerk-Maxwell, and Crookes during our days.

The definition of force shows us that whatever changes or tends to change the motion of matter (or of the molecules of which it is composed), by altering either its direction or its magnitude, is a form of force. Thus gravity is a form of force, for it attracts all matter to the centre of the earth, and it is measured by the rate per second at which a body acquires a velocity in this direction when falling freely at a given spot. Heat is a form of force, for it throws the molecules of matter into violent vibration, or it increases the velocity of their motion in straight lines, which thus becomes the measure of its heat or its *temperature*. Light is a form of force, for it is produced by the undulation of the molecules of matter, and it is transmitted by the undulations of that medium called Ether, which fills all space.

No man has seen or can see a molecule, nor have we any objective idea of what force really is. When we attempt to reach beyond these definitions, we tread upon the threshold of the holy of holies, on whose confines only are we permitted to dwell, and into which we are not yet allowed to enter. "Hitherto shalt thou come, but no further, and here shall thy proud waves be stayed." Let us, therefore, be content with precise definitions and clear mental conceptions, speculative though they be, of matter inert and of matter in motion. The *ultima thule* of the scientific man is theory, and at any time his most cherished notions may be

> "Melted into air, into thin air."

The scientific man, while rather too fond of decrying the exercise of faith in others, is himself the humblest slave of the imagination. A physical theory may be complete. The various facts and laws which it embraces may be related mathematically with one another, yet one single incompatible phenomenon may dissolve it,

> "And, like this insubstantial pageant faded,
> Leave not a rack behind."

Hence, while apparently dogmatic in my description of the present theory of matter and force, I wish it distinctly to be understood that it rests, and must continue to rest, on the imaginative power of the mind.

Nevertheless, subjective speculation may become objective reality. Who is there that doubts the existence of the ether filling all space, transmitting those exquisite and delicate vibrations which impart to us the sensation of light and heat from stars and nebulæ countless millions of miles away? And with regard to the atomic structure of matter, though but a speculation as yet, it is so complete, so apt, and so thorough, that for my part, I have not the slightest doubt of its reality, and therefore I submit it with apparent dogmatism.

When we take a given free mass and impress upon it a given force, we throw that mass into motion; for instance, when we fire a loaded cannon, we have imparted to the ball "*energy*," and in virtue of the motion of the ball, this energy is called "*kinetic*." Again, if we lift the ball to a certain height above the earth's surface—say to the top of a tower—and let it remain there, we have again imparted to it "energy," but this time it is called "*potential*," for it is dormant or resting. In each case the energy possessed by the ball is the exact equivalent of the work done upon it, that is, of the force impressed and the distance through which it has acted. The motion of the ball is readily transferred to the motion of the individual molecules of the ball. When, in the first case adduced, the ball strikes the side of a ship or a target, its kinetic energy is thus converted into light and heat, which is molecular motion; or, in the second case, when it is allowed to fall, its potential energy is converted into kinetic energy, which again, on coming in contact with the ground, is converted into molecular motion or heat. Energy is always either potential or kinetic, and one of the most remarkable generalisations of modern days is the grand principle of the conservation of energy, which implies that the total energy of the universe is a quantity which can neither be increased nor diminished, though it may be transformed into any of the forms of which energy is susceptible. Energy is therefore as indestructible as matter. All the recent advances in the science of heat have been due to the discovery of this principle, and its application to electricity has gone far to remove that science from the hypothetical state in which it has existed so long.

My purpose is to contend that electricity is not a form of matter but a form of force, and that all its effects are evident to us in one or other of the several forms of energy characterised by the motions of molecules or of mass.

It is interesting to trace the historical growth of theories. The uncultivated human intellect cannot soar above its own limited sphere of childish observation. Whatever is mysterious and incomprehensible in nature is attributed to that which is equally mysterious and incomprehensible. Life has ever been of this character, and heat, magnetism, electricity, and many other unaccountable physical phenomena, have each in their turn been supposed to be cases of life. Even now there are those who would attribute exceptional and peculiar phenomena to spiritual agencies.

Heat was thought by the Greeks to be an animal that bit. It was then for many centuries thought to be a fluid which, entering into bodies, like mercury, made them swell, and this idea existed until this generation,

when Rumford showed it to be a kind of motion, and Joule made it a quantitative form of energy.

Thales, of Miletus, thought that the magnet was endowed with a sort of immaterial spirit, and to possess a species of animation. The Greeks knew also that rubbed amber attracted bits of straw, and supposed it to be endowed with life. Even Boyle, as late as 1675, imagined it to emit a sort of glutinous effluvium which laid hold of small bodies and pulled them towards the excited body. Du Fay in 1733 conceived the double fluid theory, and Franklin in 1747 invented the single fluid theory. Cavendish in 1771 supplied some of the deficiencies of Franklin's theory, but it was Faraday who first exploded the fluid notion and originated the molecular theory of electricity, while Grove boldly classed electricity with light and heat as correlated forces and mere modes of motion.

Light was thought by the Platonists to be the consequence of something emitted from the eye meeting with certain emanations from the surface of things, but no theory of light properly so called was attempted until Newton produced his celebrated corpuscular theory in 1670, which has lasted until the present day. Even as late as 1816 Faraday himself said: "The conclusion that is now generally received appears to be, that light consists of minute atoms of matter of an octahedral form, possessing polarity, and varying in size or in velocity."* Although Huyghens in Newton's own time conceived the undulatory theory, the superior authority of the great English philosopher overshadowed the lesser light, and it was not until Young and Fresnel at the commencement of this century took the matter up, that the present theory of light took firm root.

Thus we see that all these sciences have passed through the same stages of mystery and fancy, and it is only within the present generation that they have emerged from the mythical to the natural, from mere hypothesis to true theory. *Hypothesis* is an imaginary explanation of the cause of certain phenomena which remains to be shown probable or to be proved true. *Theory* is this supposition when it has been shown to be highly probable and all known facts are in agreement with its truth.

A theory, therefore, to be valid and true, must agree with every observed fact; it must not conflict with natural laws; it must suggest new experience, and it should lead to further developments. A theory is absurd if it supposes an agent to act in a manner unknown in all other cases. The fluid theories of electricity are merely descriptive, they do not agree with every observed fact; they have never prompted the invention of a single new experiment, or led to any development. They suppose an agent unknown in other cases and opposed to natural laws. Incomplete theories die a natural death, thus Descartes' vortices, Newton's corpuscular theory of light, the fluid theory of heat, Stahl's phlogiston, Nature abhorring a vacuum, have all disappeared, while complete theories, such as that of gravity, the laws of motion, the conservation of energy, the undulatory theory of light, not only remain, but suggest new fields of inquiry, open out fresh pastures, carry truth and conviction with them, and have led to the most wonderful predictions. The fluid theories of electricity are certainly incomplete, and they deserve a speedy interment. We have to assume the existence of two substances of opposite qualities which mutually annihilate each other on combination—a self-evident absurdity, for the conception of matter involves indestructibility. Franklin imagined his one fluid to be an element of glass; remove electricity, and glass would lose its virtues and properties, and thus glass was to give out its electricity for ever and a day, without loss of weight or sensible diminution. It was to be devoid of dimensions, inertia, weight, and elasticity, and is therefore outside the pale of our definition.

Electricity is therefore not a form of matter. Hence, according to our reasoning, it must be a form of force.

But can we not prove that it is a form of force? Certainly.

Let us first argue from analogy. We know that sound, heat, and light are modes of motion, in what respects does electricity agree with these forms of force?

The fundamental law of electrostatics is that two bodies charged with opposite electricities attract each other with a force dependent on the square of the distance separating them. Whatever influence or power spreads from a point and expands uniformly through space varies in intensity as the square of the distance for the area over which it is spread increases as the square of the radius. This is the case with gravity, light, sound, and heat, which are known forms of force. It is also the case with electricity and magnetism, which ought therefore to be similar forms of force.

If we regard the velocity of transmission of certain electrical disturbances through space, we have every reason to believe that it is the same as that of radiant heat and light. In 1859 two observers in different parts of the country (Messrs. Carrington and Hodgson) saw simultaneously a bright spot break out on the face of the sun, whose duration was only five minutes. Exactly at this time the magnetic needles at Kew were jerked, and the telegraph wires all over the world were disturbed. Telegraphists were shocked, and an apparatus in Norway was set on fire. Auroras followed, and all the effects of powerful magnetic storms. Moreover, the periods of sun spots, earth currents, and magnetic storms follow the same cycle of about eleven years. Dr. Hopkinson has shown that this electric disturbance through space is as mechanical as its action through short distances, and is therefore identical with the ordinary strains of elastic matter subject to distortion by mechanical force. But Clerk-Maxwell has gone beyond this, and has shown that the velocity of light is identical with that of the propagation of electrical disturbances through space as well as through air and other transparent media. Hence, as light is admitted to be a mode of motion identical with radiant heat, electricity must be of the same category.

There is such a remarkable analogy between the conductivity of the different metals for heat and for electricity—indeed, there is every reason to believe that if the metals were pure, the order and ratio of conductivity would be identical—that it is impossible to resist the conclusion that the mode of transmission in each case is the same. Mr. Chandler Roberts, who, using Prof. Hughes' beautiful induction-balance, showed, by experiments on a comprehensive series of alloys, that the curves indicating the induction-balance effect closely resemble their curves of electrical resistance. He was also able to demonstrate that the induction-balance curve of the copper-tin alloys is almost identical with the curve of the conductivity of heat: a conclusion of much interest; and he pointed out that we might look with confidence to being able to ascertain, by the aid of the induction-balance, whether the relation between the conductivity of heat and electricity is really as simple as it has hitherto been supposed to be. Moreover, when a wire conveys a current of electricity it is warmed, as the strength of current is increased it is heated and eventually rendered incandescent. The ultimate form which every electric current takes is heat. The wire of every telegraph is warmed in

* Life, vol. i. p. 216.

proportion to the currents it transmits. Joule showed that when this heat is produced by a current generated in a battery by chemical force, its amount is exactly equivalent to that which would have been evolved by the direct combination of the atoms. The conducting power of all bodies is affected by heat, and some even, like selenium, by light. Hence, as we know that in the case of heat and light conduction is molecular vibration, we reasonably conclude that it is the same with electricity. In fact, it is impossible to account for these phenomena except on the assumption of the motion of the molecules.

The magnificent researches of Dr. Warren de la Rue and Dr. Hugo Müller on the electric discharge with the 11,000 cells of chloride of silver battery that the former philosopher has provided himself with in his celebrated laboratory, have shown indisputably that the discharge in air or in gases under various pressures is a function of the molecules filling the space through which the discharge occurs. In fact, the resistance of the discharge between parallel flat surfaces is as the number of molecules intervening between them; and they show that during electrical discharge in a gas there is a sudden and considerable pressure produced by a projection of the molecules against the sides of the containing vessel distinct from that caused by heat, and unquestionably due to the molecular action of electrification. The long-continued and patient researches which these eminent physicists are carrying out prove beyond doubt that electrical discharge is simply molecular disturbance. In reality, the fact that no discharge occurs through a perfect vacuum is a crucial proof of the molecular theory.

Some recent very remarkable researches of M. Planté with his rheostatic machine* have shown that fine wires conveying powerful currents are wrinkled up into well defined regular nodes, that these effects are accompanied by a peculiar crackling, and that the wire itself becomes brittle, giving clear indication of the vibratory motion of the molecules. He gives as the result of his inquiry that electrical transmission is the result of a series of very rapid vibration of the more or less elastic matter which it traverses, and he points out certain analogies between electric motion and sonorous vibrations. This view has been supported by the researches of Professors Ayrton and Perry† on the viscosity of dielectrics.

Professor Challis, of Cambridge, has extended this view so far as to embrace magnetism, electricity, light, heat, and gravity in one category of physical force, and to assert that they all result from motions and pressures of a uniform elastic fluid medium pervading all space not occupied by atoms. His views, however, have not received much attention, for they are not based on the foundation of any new facts, and they are utterly subversive of many cherished principles deeply rooted in the scientific mind. It is to be observed, however, that he regards electricity as a form of force.

Mr. Crookes in his recent beautiful experimental researches into molecular physics in high vacua has still more conclusively proved the connection that exists between electrical action and molecular motion. In fact, his experiments are so brilliant, his expositions so lucid, that one can fancy one sees with the eye of the body that peculiar play of the molecules which can be evident only to the eye of the mind. Not only has Mr. Crookes established as a physical fact the kinetic theory of gases, and the molecular constitution of matter, but he has indicated the existence of a fourth state of matter where the molecules fly about without mutual let or hindrance. He has also led us to doubt the truth of the generally received opinion that an electric current flows from the positive to the negative electrode. It would appear from his investigations that the reverse is the case. Be that as it may, he has added one storey to the structure of the molecular theory of electricity.

The criterion of a good theory is, however, its power of prediction. A false theory has never led to prevision. Neither the corpuscular theory of light, nor the fluid theories of heat and electricity, ever led to the prediction of something of which eyes had not seen nor ears heard. The triumphs of prediction in astronomy, sound, light, and heat are innumerable. Faraday predicted the effect of induction in lowering the velocity of currents of electricity and the action of magnetism on a ray of light. Sir William Thomson predicted that a current in passing from a hot to a cold part of a copper bar would heat the point of contact, while in an iron bar it cools it. Peltier predicted the cooling effect of currents on the junctions of thermo-electric pairs.

But the true identity of these physical effects is conclusively shown by their quantitative character, and by their adhesion to the law of the conservation of energy. Take the case of the electric light: the consumption of coal in a furnace generates steam, the steam works an engine, the engine rotates a coil of wire in a magnetic field, the motion of the coil in this field induces currents of electricity in the wire, these currents of electricity produce an arc, and thereby heat and light. The energy of the coal is transformed into heat and light through the intermediate agency of electricity. Is it possible to conceive that this intermediate agency is anything but a form of energy? Take the case of the Bell telephone: the energy of the voice produces the energy of sonorous vibration in the air, the vibrations of the air cause the vibrations of the iron disc, the vibrations of the disc vary the magnetism of the magnetic field, this produces currents of electricity in a small coil in this field which vary the magnetism of the distant magnet, which in its turn throws its disc armature into vibration, and thereby repeats at the distant station the sonorous vibrations of the air, and thus reproduces the energy of the voice. A tuning-fork comes to rest sooner in front of a telephone than when it is allowed to vibrate freely in air. Here we have the energy of the fork passing through the several stages indicated above, and ultimately come out in its original form. The energy of sonorous vibrations at the distant station is that lost by the vibrating tuning-fork.

Is it possible to assume that in this cycle of changes energy has been transformed into matter and matter again formed into energy? It is impossible and absurd. Clerk-Maxwell said: "When the appearance of one thing is strictly connected with the disappearance of another, so that the amount which exists of the one thing depends on and can be calculated from the amount of the other which has disappeared, we conclude that the one has been formed at the expense of the other, and that they are both forms of the same thing."

Would it be possible to light the streets of New York by the energy of the falling water at Niagara, as has been suggested by our Past President, Dr. Siemens, if the cycle of changes from the one spot to the other were not all different forms of this same energy? Would it be possible to plough a field a mile away from the source of motive power of the transmitting medium if the electric currents were not forms of the same power? Electricity in its effects is and must be a form of energy.

* Comptes Rendus, lxxxix., pp. 76—80, 1879.
† Pro, Roy. Soc., pp. 7, 8, No. 186, 1878.

The final stage into which any physical theory grows is that in which every action can be expressed in mathematical language, where every phenomenon is calculated upon an absolute physical basis, and where we can foretell exactly what will occur under any possible emergency. This is the present condition of the science of electricity. We can calculate exactly how much steam power is required to generate a given current to produce a given light. We can tell precisely what dimensions of cable are necessary to give a certain number of words per minute on the other side of the globe. If a fault develop itself in a long cable through the gastronomic propensities of a thoughtless young teredo, we can calculate to within a few fathoms the locality of his edacious depredation.

Take, again, the conversion of heat into electricity, and of electricity into heat, of chemism into electricity, and of electricity into chemism—but I am tired of these illustrations. It may suit a Darwin or a Faraday, to satiate his pupils with a plethora of illustrations to carry his point, or it may suit an author who is writing a book to exhaust his subject, but the President of a Society in his inaugural address must regard the time before him and the patience of his readers. I have shown that electricity is not a form of matter, and I hope I have now convinced you that it must be a form of force. In its effects which are known to us, it must rank as one form of energy in the same category with chemism, with light, and with heat, as a peculiar mode of motion of the molecules of matter.

Clerk-Maxwell,* in his classical work on electricity, has used a somewhat curious argument to show that electricity is not, like heat, a form of energy. He says that energy is produced by the multiplication of "electricity" and "potential," and that it is impossible that electricity and energy should be quantities of the same category, for electricity is only one of the factors of energy, the other factor being "potential." But this does not militate in any way against the force of the argument, for in nature we can no more do so than we can separate heat and temperature. Energy usually appears as the product of two factors, and it is the equivalent of the work done. Thus, *Potential energy* is the product of mass and gravitation acting through a distance. *Kinetic energy* is the product of mass and the half-square of velocity. The energy of fluids is the product of volume and pressure. The energy of heat is made up of heat and temperature, and the energy of electricity is the product of electricity and potential. Hence it is that electricity, *per se*, may be said to be a form of force, while all its effects as known to us are forms of energy. Force alone cannot produce energy; it must be force and something else. Force is the power of producing energy, and it must have something on which to produce it. Hence matter is always present; and thus, though heat, light, and electricity are forms of motion, they are in reality properties of matter from which they are inseparable. They are evident to us through the play of the molecules of matter, and thus are properly called molecular forces.

Our Society was established for the general advancement of electrical and telegraphic science, and more particularly for facilitating the exchange of information and ideas among its members. The advancement of physical science is as much our duty as is the furtherance of the art of telegraphy. Complaint has been made that we have devoted ourselves too much to the ventilation of purely concrete matters, while abstract questions have been neglected. There may be some truth in this stricture on our proceedings, and there may even be a cause for it. The Council are now seriously considering, not perhaps so much an enlargement of the scope of the Society as an alteration in its title, which will prevent any misconception as to its aims and purposes. Though the science of electricity is very advanced, there is still vast room for research, and our widely scattered members, spread all over the face of the globe, with the most costly and perfect apparatus at their command, have a grand opportunity to further the objects of the Society, if they only avail themselves of the means at their disposal. Every science, and especially our science, is the outcome of intelligent observation and careful experiment. There is no science that owes so much to its practical employment for useful purposes. The science itself has grown with the art of telegraphy. Practical difficulties have suggested inquiry, inquiry has prompted trial, trial has opened the eye of the mind to further development, and the result is that the highest scientific authorities acknowledge their indebtedness to the telegraph engineer. The historical inductive philosophy of Bacon is supposed to teach us that to establish science on a true basis we must accumulate a vast array of facts, marshal them in proper methodical order, and extract from them laws. But this is not the natural order, nor is it the method pursued by Newton, Faraday, or any great master of science. Joule has spoken of "a new era in the history of science, when the famous philosophical system of Bacon will be to a great extent superseded, and when, instead of arriving at discovery by induction from experiment, we shall obtain our largest accessories of new facts by reasoning deductively from fundamental principles."*

Faraday said: "I must keep my researches really *experimental*, and not let them deserve anywhere the character of *hypothetical imaginations*."† Nevertheless, all Faraday's researches are characterised by the hand following the brain; by observation and experiment checking, as it were, the speculations of thought. For forty years he pursued his pet notion of the connection between magnetism and light. He was sure it existed, but it took him twenty-three years to prove it.

Jevons said: "Modern science is not the result of the Baconian philosophy, it is the result of the Newtonian philosophy and the Newton method. The 'Principia' is the true 'Novum Organum.' It is the result of theory guiding experiment, and yet wholly relying on experiment for confirmation; the brain guiding the hands."‡ In our practice difficulties have suggested remedies, effects have suggested causes, hypothesis has suggested experiment, and experience has confirmed or refuted the hypothetical anticipations of the fertile brain. The difficulties in working underground wires, and in cables, suggested to Faraday and to Thomson those researches which have placed the laws of induction on "the solid ground of nature." The necessities of the telegraph engineer prompted the members of the Committee of the British Association to labour with such success as to bring the physical quantities of electrical elements within the fold of exact and absolute measurement. We glory in the present day in the perfection of apparatus which the requirements of telegraphy have evoked, and experiments which Newton would have thought too minute to fall under the observation of our senses are repeated every day. The indications of Thomson's reflecting galvanometer, and the beats of Bell's telephone are only equalled by Whitworth's gauges and by spectrum analysis.

The development of ocean cables has opened a new

* Vol. i. p. 30.

* Phil. Trans. 1858.
† "Life of Faraday," vol. ii. p. 35.
‡ "Principles of Science," vol. ii.

world to the scientific observer, and *Porcupines*, *Lightnings*, and *Challengers* have probed the deep unfathomed caves of ocean, swept the bed of the mighty deep, and scoured the surface of the seas, to search out new facts, and to open up fresh fields for the naturalist, the biologist, and the meteorologist. There are many questions that remain unanswered, and that offer work for our members: the distribution of atmospheric electricity, the conductivity of the atmosphere, the cause and nature of earth currents, the electrical relation that exists between the sun and the earth, the cause of electrification or polarisation in insulated wires, the various phases of induction, and many other points deserve inquiry for report to the Society for discussion at our meetings, and for record in our proceedings.

Earth currents have been a favourite subject of inquiry of mine for many years. I have always entertained the idea that they are directly due to the action of the sun. Some disturbance in the sun causes, by induction, a variation in the distribution of the lines of potential on the earth's surface, and produces the conditions required for these currents. I have many facts to support this hypothesis, but I want more to confirm it. Professors Ayrton and Perry have developed a theory of terrestrial magnetism based on the assumption that the earth is a highly electrified sphere, which not only coincides well with facts, but which tends greatly to support my views. I want observers to record the times of daily maxima and minima. I want them especially to note during those periods of unusual disturbance the direction of the circuits which are *not* affected, for they would give the direction of the lines of equipotential. This not only offers a useful field of observation, but its failure or success will illustrate the modern method of scientific research, when the brain suggests to the hand and the eye what they have to do, and what they have to look for.

Our Society not only offers a useful field for scientific research, but it supplies a very useful arena for the education of its members. We shall shortly have open to their perusal the finest electrical library in the world—that of Ronalds, and we have the hopes in the future of having added to it an equally famous one, collected by one of our most eminent Past Presidents.

But knowledge gained from books should be confirmed by experience. We are too much apt to rely on illustrations, and think we know all because we can illustrate it by pen or pencil. Many a bright idea is lost for want of an opportunity to test its validity. Those who reason theoretically without demonstrating experimentally are sure to fall into error, while those who experiment in a haphazard way without being guided theoretically, are sure to waste time and money. I want, therefore, to see our library supplemented by a laboratory, where those of our members who have not the means at their disposal, can not only confirm their reading, but go and examine their ideas for themselves by the rigorous test of experiment. We are not all Hughes who can make scientific apparatus out of lucifer boxes and bonnet wire. If the financial abilities of our Hon. Treasurer prove as successful in the future as they have done in the short career which has distinguished his past occupation of the office, I have little doubt that this wish will be within reach of accomplishment.

There is no more useful mode of imparting knowledge than that of lecturing. "It blesseth him that gives and him that takes." The lecturer often learns more than his audience. The possession of a laboratory would enable us to ask those who have made any special line of study their own, to favour us occasionally with a *vivâ voce* explanation of their researches and their views. Several societies practise this salutary plan, which is one that was very strongly advocated by Faraday.

Our proceedings form a most useful vehicle for the promulgation of new facts. History tells us of many brilliant experiments and discoveries that have been hidden and neglected from the want of proper publication, or of some society to take them up. Thus Mayow, a doctor of Bath, discovered oxygen over 100 years before it was re-discovered by Priestley and Scheele. Romagnosi, a doctor of Trent, discovered the deflection of the needle 15 years before Oersted startled all Europe with its re-discovery.

The great cry of to-day is for technical education. Here we have an organisation well suited for furthering this object, and with a home of our own, an unequalled library, and a well-equipped laboratory, we ought to be able to stifle the cry, at least as far as telegraphy is concerned.

The science of electricity owes its great development to the vast extension of submarine telegraphy throughout the oceans of the world. The Atlantic has been crossed by no less than nine cables, of which three, however, are dumb. A thin cord duplicated the whole way, extends from England to Australia, it is duplexed to India, and one wire extends from Aden to the Cape. There are no less than 97,568 miles of submarine cable now in working order. In spite of the wail of distress that has depressed the commercial world, cable enterprise has not fallen below the average during the past year.

During the past twelve months the Telegraph Construction Company has manufactured 6,800 knots, Siemens Brothers 3,600 knots, the Silvertown Company 900 knots, and Mr. Henley 107 knots of cable—11,407 knots of cable laid by commercial enterprise in all quarters of the globe in one year!

The maintenance of the long mileage of cable requires the employment of a fleet of ships. There are now no less than 27 steamships employed for telegraphic purposes in different parts of the globe. They are all well officered, and specially fitted up with machinery and apparatus to facilitate their operations. They are each provided with a skilled staff specially trained to observation and experiment. We are much indebted to Mr. Jamieson for a very interesting paper on Cable Grappling and Lifting, but with this exception we have little or nothing to chronicle of their doings. It is surprising how few are the facts that have been added to our knowledge by such an organisation. It is owing certainly not to want of zeal, but perhaps to an ignorance of what is needed. If they were to study Sir Wyville Thomson's "Depths of the Sea," or his "Voyage of the Challenger," if they were to provide themselves with a good microscope, with sample bottles and alcohol, they would be surprised to find how much they would increase their own enjoyment, afford gratification to their friends at home, and further the interests of science. Indeed, ocean life is becoming a source of considerable anxiety to the telegraph engineer, for many little creatures have developed a decided *penchant* for the constituents of which cables are composed. In all the recent cables laid within depths of 100 fathoms by the Telegraph Construction Company a wrapping of thin brass has been externally applied to provide for this growing evil. Damage to the gutta-percha has not been observed at greater depths than 100 fathoms, but some specimens of the Atlantic Cable of 1865, which have recently been recovered from a depth of 2,000 fathoms, gave unmistakable evidence of the destruction of the hemp by some boring animal.

At home the greatest advances have been made in apparatus. The mileage of wire that has been erected

in England to meet the enormous increase of telegraph business that has occurred since 1871 is trifling. The average weekly number of messages in the month of October, for the former year, was 273,000, the greatest number ever reached at that time, while for this last year it amounted to no less a figure than 586,000. This great increase has really been provided for by the improvement in Wheatstone's Automatic Apparatus; by the introduction of duplex working, and more recently by the quadruplex system. The duplex and quadruplex systems have been proved to be applicable to automatic working, and the speed of working long circuits has been much increased by the insertion of intermediate relay stations. But we have reached a limit; our system is actually gorged with messages; failures of wires cause considerable trouble, inconvenience, and complaint, the public—our watchful, but not lenient masters—are beginning to growl, and the erection of additional wires has become essential. It is hoped that a new trunk line to the North and many additional wires will be erected during the ensuing summer. There is also strong reason to believe that for the first time since the acquisiton of the Telegraphs, the balance on the right side will be sufficient to show a surplus over the dividend on the capital expended in the acquisition of telegraphs by the State.

The improvement of apparatus in this country is a veritable case of growth by evolution. The instruments themselves are in a constant state of transition. Every defect or deficiency, as it develops itself, is removed, and the result is that the instrument grows by a process of careful cultivation and of intelligent selection, prompted by experiment, guided by theory, and confirmed by practice. It is not too much to say that in quality of manufacture, efficiency of performance, and perfection of design, the apparatus of this country takes its position in the very front rank. This applies not only to the apparatus used by the Post Office, but essentially to that employed by the Cable Telegraph Companies. Even lately a very great step forward has been made by Mr. Harwood, of the Eastern Telegraph Company, who has recently much improved the duplex working of cables both as regards speed and efficiency.

The cry that invention has been checked by the monopoly of the Government is made by those who are ignorant of contemporaneous history, who are too callous to inquire for themselves into the truth of the accusation, and with whom most probably the wish is father to the thought.

The telephone—the great excitement of the previous session—has made but little progress during the past year, though there is no doubt that, through the discovery of the principle of the microphone by Professor Hughes, the practical applications of that wonderful instrument have been much improved. In fact, Professor Graham Bell, Mr. Edison, Mr. Elisha Gray, and all those who have been working in this field, have laid aside their own particular form of transmitter, and have adopted one that is a mere form of microphone. In England we have one or two excellent forms. Those of Mr. Louis Crossley and Mr. Hunnings leave little to be desired, while in America that of Mr. Francis Blake is admirable, and is also much used in England.

Litigation has commenced between the Post Office and the Telephone Companies, not to restrict, or in any way to interfere with the use of the telephone; but to prevent the establishment of a particular branch of post-office telegraph business without its licence or consent.

A curious controversy as to the seat of the vibrations which result in the reproduction of speech has occupied the attention of certain physicists on the other side of the Channel. Some, following Graham Bell, and led by Count du Moncel, attribute the effect solely to what may be called the Page effect, viz., a molecular disturbance of the magnet itself. Others, led by Colonel Navez, prefer to follow me in a theory I first propounded at Plymouth,* viz., the sonorous vibrations are set up by the mechanical movement of the disc itself. Both theories are really true, and the controversy is, like many other scientific controversies, a war of words. The motion of a mass is the integration of the motions of the molecules of the mass. There is the Page effect in the magnet, and there are the effects of magnetic attraction on the disc; the resultant action being sonorous vibrations. In point of fact, there would be no sonorous vibration if there were no molar motion, and there would be no molar motion if there were no molecular disturbance.

The electric light has been making considerable progress, and is gradually forcing itself into practical use, in spite of many of the drawbacks to its employment that have yet to be removed. The lamp of the future has not yet been produced, though steadiness and duration have very much advanced during the past twelve months. There is very little room for improvement in the generating machine, for both the Siemens and Gramme machines convert about 90 per cent. of the energy thrown into them into electric currents, and this is a duty which no other kind of machine can show.

One of its most notable and useful applications has been on board ship, to further the operations during the night in laying and repairing cables. I was present on board the s.s. *Dacia*, in the Mediterranean, when this was done, and the success was unequivocal.

The Brush machine has recently been introduced into this country, and its performances are certainly very wonderful. It produces an electromotive force of over 800 volts, and I have seen it maintain twenty very steady arcs joined in series. Sixteen appear to be its efficient limit, and this number of lamps, giving over 1,000 candlepower, are easily maintained by an expenditure of 13½ horse-power. The performances of the Brush light are certainly the most advanced form the electric light has yet taken. There are over eight hundred of these lights in the United States; and it is worthy of notice that it has quietly crept into existence without the aid of the ubiquitous and omniscient newspaper correspondent, or the transmission of any sensational telegrams, to the detriment and discomfort of gas shareholders.

It is assumed by many that the electric light is devoid of heat, but Professor Dewar has shown that a Siemens arc radiates heat equivalent to 3 horse-power per minute. Moreover, the use of such powerful currents, unless carefully directed, are dangerous to life and limb, and may even, unless properly protected, result in fire.

Gas is not going to be affected by the electric light. The proper function of gas is to generate heat. Ninety-four per cent. of the ingredients of gas are consumed in generating heat, and only six per cent. in producing light. It is remarkable that so amenable and tractable an agent for heating purposes has not been more utilised, but the fact is that the public is ignorant of its properties, careless of its employment, and callous of its defects. It is not too much to say that fifty per cent of the gas manufactured is absolutely wasted for illuminating purposes by the wild extravagance with which it is burnt, and by the want of those systems of regulation which have been introduced to compensate for irregularities and excesses of pressure.

* British Association Meeting, 1877.

The utilisation of the illimitable wasted energy on the earth's surface offers a fine field for the ingenuity of the electrician. The tides of the ocean, the motion of the atmosphere, the rapids of a river, the innumerable waterfalls that are found in every mountainous or hilly country could be compelled to give up in the form of electric currents that energy which gives them existence, and which could thus be employed for providing power, generating heat, or supplying light, away altogether from their source of conversion. In fact, Sir William Armstrong, near Newcastle, and an enterprising hotel proprietor in Switzerland, have already produced light in their houses by converting into that form the energy of a neighbouring waterfall.

I cannot omit mentioning the researches of Professor Hughes. Here we have the case of a telegraphic engineer who has spent the best part of his life in improving the working of telegraphs, resting from his labours with well-lined purse, and turning philosopher. Spurning the costly apparatus of the philosophical instrument maker, he takes the simplest and cheapest materials he can lay his hands on, and with fine inventive skill, aided by an instinctive mechanical turn of mind and well-trained hand, he forces nature to develop unexpected secrets, and he enables the chemist of the mint to detect an infinitesimal trace of impurity in the bright golden sovereign. Moreover, he has not only detected an absolute zero in nature, but he has given the physician a standard by which he can measure the relative sensitivity of the dullest and sharpest ears. His induction balance and audiometer are fit sequels to his microphone, and I venture to predict that he will yet wring out of Dame Nature some other facts that have lain dormant since the first fiat went forth, "Let there be light." His mode of investigation is a very apt illustration of the practice I have previously described as so successful in modern scientific discovery, of making experiment subservient to hypothesis with the view of furthering science. His investigations have been made without the slightest idea of gaining filthy lucre or of taking by a flank movement some successful inventor's patent—practices which, I am sorry to say, in these immoral times are far too frequent to be palatable.

We cannot but congratulate ourselves upon the position of our Society. Our first President, Dr. Siemens, in the first paragraph of his inaugural address, remarked that, "Some years must necessarily elapse before our Society can have given substantial proof of its useful action." I venture to submit that those years have passed. Our success has exceeded the most sanguine anticipations. Our work has been thought of sufficient importance to merit special reference in the first annual address of the gifted and able President of the Royal Society. The good that our Society has done and is doing is patent to all. It stimulates thought, it encourages experience, it furthers the science, and it develops the art of telegraphy. It inculcates knowledge, and is, therefore, educational; it records results, and is, therefore, historical; it cements friendship and promotes good fellowship, and it has, therefore, a moral influence; but, above all, it knits together in one family bond that great wide-spread brotherhood who are found scattered in every quarter of the world, maintaining and operating "The wonder-working wire," to the annihilation of space and the economy of time.

---

THE Second Course of Cantor Lectures for the present Session of the Society of Arts is on "The Manufacture of India-rubber and Gutta-percha," by Mr. Thomas Bolas, F.C.S. The course commences on February 2, and will be continued on successive Mondays, till March 8.

## JAMES CLERK MAXWELL, F.R.S.

(*Continued from page* 21.)

While Professor of Physics at King's College, London, Maxwell was engaged as a member of the British Association Committee in the determination of the Absolute Unit of Electrical Resistance, and it was the comparison of electrical units which attracted a great part of his attention during his tenure of his Cambridge Professorship. He always spoke very highly of Faraday's "Experimental Researches," which he read very early in life, and to which he attributed some of his most useful ideas on electricity and electro-magnetism. In Clerk Maxwell Faraday found a mind constituted after the same plan as his own, but with the advantage of a mathematical training, which has made Professor Maxwell capable of interpreting Faraday's bold realisations to the mathematical world. For Clerk Maxwell's own views of Faraday the reader may be referred to the article "Faraday," in the ninth edition of the "Encyclopædia Britannica," and to his papers on "Faraday's Lines of Force," read before the Cambridge Philosophical Society in 1855 and 1856.

It is impossible in a sketch like this to give anything but the most superficial view of a character so noble in all its aspects as that of Clerk Maxwell. As a professor he was wonderfully admired by those who were truly his disciples. He had not the power of making himself clearly understood by those who listened but casually to his pithy sentences, and consequently he was not a so-called popular lecturer; nor was he a most successful teacher of careless students. But when he had those about him who could enter into his mind, and, receiving the golden truths from his lips, could alloy them in such a way as to make them acceptable to the ordinary student, no better teacher could be desired, even for the most elementary instruction. His wonderful imagination was of great value, not only in supplying illustrations for didactic purposes, but in suggesting analogies and opening up new fields for research, though in the lecture-room it sometimes carried him on more rapidly than the ordinary members of his class could follow.

The pages of *Blackwood's Magazine* (Nov., 1874) can testify to his talents as a poet; his sense of humour and his ready wit formed remarkable features in his character, in fact he seldom talked for many minutes without provoking at least a smile. (Some of the reviews lately contributed by him to *Nature* may serve as illustrations.) He was well versed in all the literature of the day, and seemed to have investigated on his own account every system of philosophy. He took great interest in passing events, though he never indulged in political discussions. As an experimentalist he was too well known to require description; in that region of science which was his *par excellence*, viz., the domain of Molecular Physics, he stands without a rival. But there were other sides of his character which outshone even his scientific attainments. Such complete unselfishness and tender consideration as he exhibited for those around him, and especially for those under his control, are seldom to be met with. During the eight years that he held the chair of Physics in Cambridge he never spoke a hasty

word, even to his attendants. His self-sacrificing devotion to those he loved was the marvel of his friends. Though he never entered into theological controversy, and only occasionally in his scientific writings indicated in a sentence or two the side he took in questions which have recently been brought prominently before the public by some of the more popular men of science, those who had an opportunity of seeing into his home-life knew him to be an earnest Christian. About three weeks before his death he remarked that he had examined every system of Atheism he could lay hands on, and had found, quite independently of any previous knowledge he had of the wants of men, that each system implied a God at the bottom to make it workable. He went on to say that he had been occupied in trying to gain truth, that it is but little of truth that man can acquire, but it is something to "know in whom we have believed." His simple Christian faith gave him a peace too deep to be ruffled by bodily pain or external circumstances, and left his mind free to the last to contemplate all kinds of questions of general interest. One day not long before his death he had been puzzling himself in vain endeavours to discover why Lorenzo ("Merchant of Venice," Act. v. scene 1), whose character was at least far from noble, says to Jessica—

> "Look how the floor of heaven
> Is thick inlaid with patines of bright gold:
> There's not the smallest orb which thou beholdst
> But in his motion like an angel sings,
> Still quiring to the young-eyed cherubins;
> Such harmony is in immortal souls;
> But while this muddy vesture of decay
> Doth grossly close it in, we cannot hear it."

We may quote one other example illustrating how the speculative character of his mind remained to the last. About five or six days before his death, when he was suffering from such extreme weakness that he could say very little, after lying motionless with his eyes closed for some time, he presently looked up and remarked, "'Every good gift and every perfect gift is from above, and cometh down from the Father of lights, with whom is no variableness, neither shadow of turning.' Do you know that is a hexameter?

'πᾶσα δόσις ἀγαθὴ καὶ πᾶν δῶρημα τέλειον,'

I wonder who composed it."

His knowledge of hymns and hymn-writers was very extensive, and he took great pleasure during his illness in reciting from memory some of his favourites among the writings of Richard Baxter, George Herbert, and others.

To attempt to give any adequate idea of his contributions to science in a sketch like the present would be but to mislead the reader. His great work on "Electricity and Magnetism," the second edition of which is now in the press, is the admiration of mathematical physicists. More generally known are his treatise on the Theory of Heat, and his little text-book entitled "Matter and Motion," which was published by the S.P.C.K. His first paper, communicated by Forbes to the Royal Society of Edinburgh, on "The Description of Oval Curves and those having a plurality of foci," is dated 1846. His paper on the "Theory of Rolling Curves" was communicated to the Royal Society of Edinburgh by Prof. Kelland, and read on February 19, 1849, when Clerk Maxwell was an Edinburgh student barely 18 years of age. His paper on the "Equilibrium of Elastic Solids," above alluded to, was read before the same society on February 18, 1850. His paper on the "Transformation of Surfaces by Bending" was read before the Cambridge Philosophical Society on March 13, 1854, about two months after taking his degree. This was followed in December, 1855, and February, 1856, by papers on "Faraday's Lines of Force." In 1857 he obtained the Adams Prize in the University of Cambridge, for his paper on the "Motions of Saturn's Rings." His paper on the "Theory of Compound Colours, and the Relations of the Colours of the Spectrum," which was chiefly instrumental in gaining the Rumford Medal, was read before the Royal Society on March 22, 1860. His "Dynamical Theory of the Electromagnetic Field," including a brief sketch of the Electromagnetic theory of Light, was read before the Royal Society on December 8, 1864. The results of Clerk Maxwell's experiments on "The Viscosity and Internal Friction of Air and other Gases," were made known to the Royal Society in the Bakerian Lecture read February 8, 1866. Then follow his Royal Society papers "On the Dynamical Theory of Gases," in May, 1866, and "On a Method of Making a Direct Comparison of Electrostatic with Electromagnetic Force, with a Note on the Electromagnetic Theory of Light," in June, 1868. Lately he took great interest in Graphical Statics, and contributed a long paper "On Reciprocal Figures, Frames and Diagrams of Forces," to the Royal Society of Edinburgh, in December, 1869. This paper obtained the Keibb Medal. Among his most recent papers are a paper on "Stresses in Rarefied Gases arising from Inequalities of Temperature," read before the Royal Society on April 11, 1878, and a paper on "Boltzmann's Theorem," read before the Cambridge Philosophical Society. It would take too long to enumerate his articles and reviews published in the *Philosophical Magazine* and in *Nature*. His contributions to the ninth edition of the "Encyclopædia Britannica" include the articles "Atom," "Attraction," "Capillary Action," "Constitution of Bodies," "Diagrams," "Diffusion," "Ether," "Faraday," and "Harmonic Analysis." "Harmonic Analysis" was the last article he wrote. In 1870 Clerk Maxwell was president of the Mathematical and Physical section of the British Association. His presidential address on the "Foundation Stones of the Material Universe" is too well remembered to require more than a passing reference.

One of the most remarkable of his works is the recently-published volume of the Electrical Researches of the Hon. Henry Cavendish, of which Professor Maxwell is the editor. The MSS. are in the possession of the Duke of Devonshire, and are now at Chatsworth. They were intrusted by him to Professor Maxwell shortly after the completion of the Cavendish Laboratory. Some of Cavendish's experiments were repeated by Professor Maxwell with all the appliances of modern apparatus, and others were carried out by his pupils.

Most of the apparatus which he employed in his researches has been presented by Professor Clerk Maxwell to the Cavendish Laboratory, together with many of his books. He always regarded the

laboratory with great affection, and the University owes much to his liberality. One of the most interesting pieces of his handy-work now preserved in the laboratory is a plaster model of Professor Willard Gibbs's thermodynamic surface, described in the fourth edition of "Maxwell's Theory of Heat." All the lines on the surface are drawn by his own hand, many of them being mapped out by placing the surface obliquely in the sunshine and marking the boundary between light and shade. Another valuable model constructed while Professor Maxwell was at Cambridge is his dynamical illustration of the action of an induction coil, in which two wheels represent by their rotation the primary and secondary currents respectively, the wheels being connected through a differential gearing to which a body of great moment of inertia is attached, the rotation of which represents the magnetism of the coil. A friction break represents resistance, and a spring may be attached to the secondary wheel to represent the capacity of a condenser placed in the secondary circuit. Among other valuable pieces of apparatus presented by Professor Maxwell to the laboratory are the receiver, plates, and inertia bar employed in his researches on the viscosity of air and other gases, his colour-top, portions of the "colour-box," including the variable slits, with the wedge for measuring their width, a polariser and analyser made of thin films of stretched gutta-percha, the mechanism for illustrating the motion of Saturn's rings, a real image stereoscope, and the dynamical top, whose moments of inertia about three axes, which are at right angles to each other, can be so varied by means of screws that the axis of rotation can be made that of greatest or of least moment of inertia. When the axis of rotation is the mean axis, the motion of the top is, of course, unstable. When Professor Maxwell came to Cambridge in 1857 to take his M.A. degree, he brought this top with him from Aberdeen. In the evening he showed it to a party of friends in college, who left the top spinning in his room. Next morning he espied one of these friends coming across the court, so jumping out of bed, he started the top anew, and retired between the sheets. The reader can well supply the rest of the story for himself. It is only necessary to add that the plot was completely successful.

Professor Clerk Maxwell's papers will be placed in the hands of Professor Stokes, who is one of his executors, in order that they may be published or catalogued and preserved in such a way as to be readily available to those wishing to consult them.

A committee has recently been formed in Cambridge, having for its chairman the Master of Trinity, for the purpose of obtaining a memorial of Professor Clerk Maxwell. It is strongly felt by many that the memorial should be distinctly personal, while the advantages to be derived from the publication of Professor Maxwell's scattered papers in a collected form are admitted by all. The objects which appear to meet with most favour are (1) a marble bust, (2) a portrait, and (3) the publication of Professor Maxwell's papers and the presentation of copies to the principal libraries and laboratories. It is hoped that the funds collected will be sufficient to enable the committee to carry out each of these proposals.

WM. GARNETT.

## A LIQUID VOLTAIC ARC.

By C. V. BOYS, A.R.S.M.
(Read before the Physical Society.)

IN the spring of last year, while I was experimenting with Dr. Guthrie on liquid conductivity, it happened that I connected, with a piece of fine steel wire, the poles of the five-cell Grove's battery which drove the Froment engine. The result of this and of the few experiments which it led me to try are of such interest as to induce me to bring them before the Physical Society.

As was to be expected the steel melted and was oxidised, and the fused oxide remained attached, part to each wire. On bringing these globules of oxide together, before they had cooled, they instantly joined together, attained a very high temperature and gave out a brilliant light. On separating the wires gently the globule of oxide stretched, and became longer and thinner and hotter and so gave a brighter light, but its want of cohesion caused it to give way just as it was increasing very rapidly in brilliancy. As this result was obtained at the time of the electric light panic, I was naturally led to hope that this liquid arc, as I rather improperly called it, might develop into a useful source of light and, therefore, the few experiments that I tried upon it were made with a view to test its value as an illuminating agent.

As glass, when hot, has considerable cohesion, and also conducts electricity well, I thought I might improve the light-giving qualities of the melted oxide of iron by adding a little glass, and so producing a compound silicate containing iron. On touching it with a capillary glass tube I found I was fully justified in my conclusion, for not only could I draw it to a greater length now than before; but, even before this stretching, it gave a better light due to the increased resistance. But much glass had a disadvantage in this respect, if the liquid arc once became at all cool it was a very troublesome matter to start it again. Beside glass I tried a variety of bodies, silica, alumina, clay, lime, oxide of chromium, fluor spar, &c., without noticing any very peculiar effect except that the positive pole was always the hottest. I tried several methods of supporting the arc, and of regulating it, with only partial success, but they are not of sufficient interest to justify me in taking up your time with an account of them.

This liquid arc is of great interest in another respect, for a liquid salt should be electrolysed by the passage of a current through it. To what extent electrolysis took place in the few experiments that I made I am not prepared to say, as I have had no time to examine the properties of the arc in a methodical or quantitative manner; but, if there is electrolysis, we have a means of examining the behaviour of rare or of highly infusible bodies under the action of the electric current, for the arc, itself, may be at a far higher temperature than the pole without their melting. I find that the arc will not wet (in a capillary sense) carbon, so platinum, iron, or some other metal must be used.

There was one more effect which I noticed which is interesting in that it gives on a small scale the same appearance as the sun when observed with a spectroscope, it gives a continuous spectrum inter-

rupted by *dark* lines. I have only succeeded in seeing the sodium line reversed, and this with a small direct vision spectroscope. At first I was led to speculate on the possibility of the constituents of a liquid absorbing the same light as they would themselves give out, but the dark sodium line observed was probably due to an atmosphere of soda round the liquid arc, replenished by volatilisation from its surface.

I must apologise for bringing before the notice of the Physical Society a description of experiments so incomplete and disconnected, but as the subject is of such interest, and as my time is fully occupied in another direction, I hoped that some one more experienced, and more skilful than myself, would think it worth while to take the matter up.

## TELEGRAPHIC APPARATUS IN USE IN THE BRITISH POSTAL TELEGRAPH DEPARTMENT.

### II.

### THE SINGLE NEEDLE INSTRUMENT—*continued.*

REFERRING to fig. 2 in the last article, in order that other stations may be able to transmit signals through the instrument the arrangement of the tappers is such that when they are at rest the circuit between terminal B and terminal A through the dial is complete. The course of the current, supposing it to enter at B, in this case is as follows:—From terminal B the current passes through the dial to terminal T, thence through the left-hand hinge-block, P, and the tongue, *t*, to contact-block *k*, from there it passes to *k'* through the strap which connects the latter with *k*, which strap is secured by the thumb-screws, X and Y. From *k'* the current passes to the tongue *t'* and through the right-hand hinge-block to terminal A.

In tracing these connections it must be borne in mind that the block which supports the spring, *s*, *s'*, is not connected either with the blocks, *k*, *k'*, or with the strap which joins them, but is insulated therefrom.

### "HIGHTON'S TAPPER."

Although the form of "tapper," or pedal key, described in the last article is the one most extensively used in the post office, yet an older pattern, designed several years ago by Mr. E. Highton, and extensively used by the "Magnetic" Company, is employed in a large number of cases.

This "tapper," which is shown in perspective by fig. 7, and in general plan by fig. 8, is very simple in design, a noticeable point being that only one movable spring is employed in its construction. There cannot be less than *one* movable spring, or its equivalent, in a key, and as every additional spring used not only renders the mechanism more complicated, but more liable to derangement, the less springs, of the kind, employed the better.

It will be seen from the figs. that the apparatus consists of two ebony pedals, E and F. These pedals are attached to a wooden block at the back of the base by flat brass springs, $s^1$, $s^2$, $s^3$, $s^4$, these springs take the place of the hinges in the tapper described in the first article. The springs on each pedal are insulated from each other, both on the ebony pedals and on the back wooden block to which they are screwed, but the left-hand spring of one pedal is connected with the left-hand spring of the other pedal by means of a brass strap, shown by *x*, fig. 7. Also the right-hand springs are similarly connected by means of a brass strap fixed to the inside of the wooden block. Both these connections are shown by the dotted lines in fig. 8.

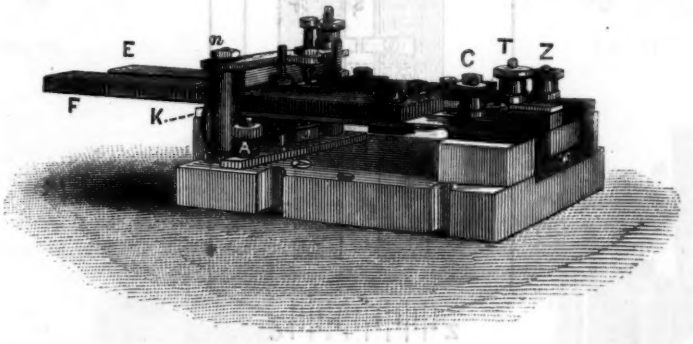



FIG. 7.

The right-hand spring, $s^2$, of the left-hand pedal is continued along underneath the latter, and is connected to the brass tongue, *t*, the lower part of which is faced with platinum. Similarly, the spring $s^3$ of the right-hand pedal is connected to the tongue $t^1$.

The left-hand spring, $s^1$, of the left-hand pedal is continued along under the latter, and is connected with the screw *b*, which passes through the pedal and makes contact, when the latter is depressed, with the end of the spring screwed to the brass block, *g*, fig. 7. Similarly, the spring, $s^4$, of the right-hand pedal is connected with the screw, *c*, which makes contact, when the pedal is depressed, with the right-hand end of the spring attached to

the before-mentioned block, *g*, fig. 7; the ends of this latter spring are bent up slightly, and when a pedal is depressed and contact is made by either of the screws *b* or *c*, they bank down upon small metal blocks placed underneath them, and both of which can be seen in fig. 7. The play thus given to the ends of the spring ensures a good rubbing contact being made.

The broad steel spring, S, fig. 8, is screwed to the back wooden block, and is provided with a terminal, T, which corresponds to the similar terminal in the other form of tapper (figs. 1 and 2, Art. I.). The portions of the spring immediately beneath the tongues, $t$, $t^1$, are faced with platinum. The further end of the spring normally makes contact with a screw, *a*, passing through the brass bridge H. The under part of this bridge is faced with leather, and against this the pedals normally rest.

The brass block, *g*, fig. 7, to which is secured the contact spring, is itself attached to a brass plate fixed to the base of the apparatus, and has the terminal A secured to it.

To springs $s^1$ and $s^4$ are secured the terminals Z and C, which, together with terminals, A and T, correspond to similar terminals in the other form of tapper.

A block, K, faced with felt, is fixed under the front of the pedals.

*Action of the tapper.*

Supposing the left-hand pedal to be depressed, then the Zinc pole of the battery becomes connected to terminal A, through the medium of the spring, $s^1$, the screw, *b*, and the spring attached to the block, *g*, fig. 7, which latter block, as was before pointed out, is connected to A. The Zinc pole is thus connected to the "Up" line. The Copper pole of the battery being in communication with the spring, $s^2$, becomes connected by the medium of the latter, with the tongue, $t$, which is now in communication with the steel spring, S, the latter having been, by the depression of the pedal, pressed away from the contact screw, *a*; thus the pole in question becomes connected with terminal T, and thence through the dial of the instrument with terminal B and the "Down" line.

If the right-hand pedal be depressed, the zinc pole of the battery becomes connected with the terminal T and the "Down" line through the medium of the spring $s^3$, the tongue $t^1$, and the spring S. The copper pole, C, becomes connected through the spring, $s^4$, with the screw contact, *c*, and thence by the spring on the block, *g*, fig. 7, with terminal A and the "Up" line; thus the direction of the current is reversed.

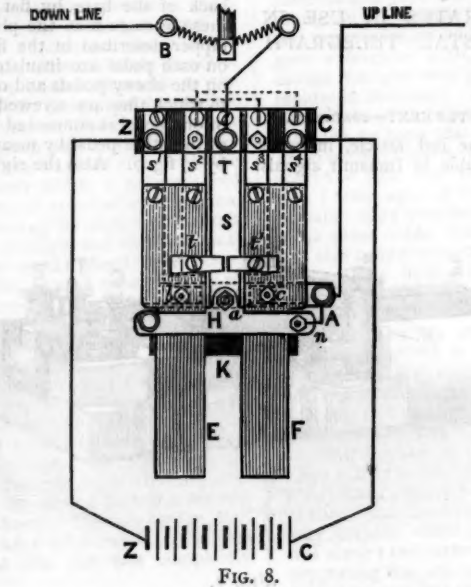



FIG. 8.

When signals are being received on the instrument from another station, then the course of the current will be, say, from terminal B, through the dial to terminal T, thence through the spring, S, to contact screw, *a*, and the bridge, H; from there the current passes to terminal A, through a connecting piece of wire which joins A with the nut, *n*.

As compared with the other form of tapper, the Highton keys are simpler in construction, but the springs, $s^1$, $s^2$, $s^3$, $s^4$, are liable to break, whereas the hinges, P, P (figs. 1 and 2, Art. I.), cannot well get out of order. If, however, good metal is used, these keys will last for a very long time; indeed, cases are known in which the wood of the pedals, E, F, has actually become worn, from constant use, to the shape of the fingers that have grasped them, and yet the brass springs and contacts have remained perfectly good.

The general appearance of the single needle instrument, when ready for use, is shown by fig. 9. The case which covers the working parts can be removed when necessary by unscrewing two thumb-screws, one on each side.

The desk which is used for supporting the message-forms projects immediately beneath the dial face; it is provided with a small hook at its upper part, on which the form can be secured from slipping down, if necessary.

The brass frame screwed to the lower part of the right-hand side of the case is for the purpose of holding a card on which are printed the names and "codes" of the stations in circuit with the instrument.

It will be noticed that there are no terminals external to the instrument, but that every wire is boxed in. The wires from the terminals, inside, in fact, all pass direct through the base of the instrument to the batteries and the line wires; this is advantageous, as it prevents "disconnections" being caused by wires being knocked off from dusting—a contingency which is very likely to occur in small offices, if precautions are not taken to avoid it.

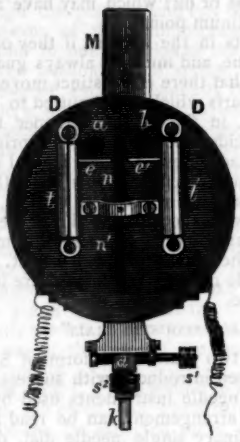



FIG. 10.

FIG. 13.

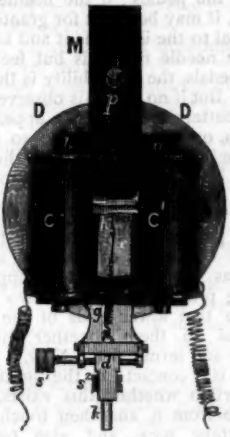



FIG. 11.

FIG. 9.

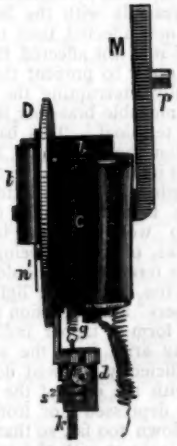



FIG. 12.

*Faults.*

The "faults" to which single needle instruments are liable are not numerous, nor, as a rule, are they difficult to detect.

A fault which interrupts the working of the apparatus may either be on the "Line," in the "Battery," in the "Dial," or in the "Tappers."

The first kind of fault may be detected by connecting terminals A and B by a piece of wire, and working the pedals; if the needle responds energetically, it may be taken for granted that the fault is external to the instrument and battery. If, however, the needle responds but feebly to the action of the pedals, the probability is that the battery is in fault. But if no signal is observed on the needle, and the battery on inspection appears to be in good condition, or is proved to be so by connecting a "detector" galvanometer to it, then the fault will prove to be in the "Dial" or "Tappers."

It will be noticed, from fig. 2 in the last article, that four terminals are provided in connection with the Dial part of the instrument; to the two upper ones the coil wires of the dial are directly connected, as are also the two upper wires of the lightning protector, *l*. The two lower terminals have the two lower ends of the protector wires connected to them, together with the "Down" line wire and terminal T. Now, a probable fault in the dial is "contact" in the lightning protector, *l*. To ascertain whether this exists, disconnect the line wire from B, and then touch the latter with one battery wire, and also touch the corresponding terminal on the right-hand side of the protector with the other battery wire; if no movement of the needle takes place, then disconnect one of the upper wires of the protector from the terminal to which it is attached, and touch the two upper terminals with the battery wires. If the needle is now affected, then the fault is in the protector; if it is not affected, then the fault is in the dial. In order to prevent the latter kind of fault from totally interrupting the other stations in the circuit, a movable brass bar is connected to the top left-hand terminal. This bar is normally left in the position shown in fig. 2, but by raising it so as to connect its free end to the top left-hand terminal, and screwing it to the latter, the dial is short-circuited; this enables the other stations in the circuit to work without interruption, the line connections, of course, being connected to their respective terminals. Should the fault not prove to be in the dial or the lightning protector, then the "tappers" must occasion the interruption.

In the form of tapper indicated by figs. 1 and 2 faults may arise from the screws at *f* and *g* not being sufficiently screwed down to make proper contact with the ends of the spring, *v*, *v'*, when a tapper is depressed; or from these screws being screwed down too far, so that the tongues, *t*, *t'*, do not make contact with the ends of the spring, *s*, *s'*; this latter fault may arise from the ends, *s*, *s'*, having become bent up. Lastly, the springs, *n*, fig. 2, underneath the tappers, may have become broken.

The faults in the form of tapper shown by figs. 7 and 8 may be due to the screw contacts, *b* and *c*, being screwed down too far, so that they touch the contacts underneath them before the tongues, *t*, *t'*, fairly move the spring, S, away from its contact with the screw, *a*. It occasionally happens that from constant use the springs, $s^1$, $s^2$, $s^3$, $s^4$, become weak and fail to raise the pedals, E, F, fairly up against the bridge, H, but allow the tongues, *t*, *t'*, to rest on the spring, S. The springs occasionally break, but, of course, such a fault is evident at once.

Faults occasionally occur in both forms of tappers from dirty contacts; but these faults are very rare, as the mechanical action of the tapper, and the jars occasioned by their use are usually quite sufficient to dislodge any dust or dirt which may have accumulated on the platinum points.

Intermittent faults in the tappers, if they occur, are very troublesome, and must be always guarded against by seeing that there is a distinct movement in the springs or parts which are required to have play; for instance, in the Highton tapper there must be a very decided movement of the spring, S, away from the contact screw, *a*, when a pedal is depressed. A slight movement of S *may* be all that is necessary when the tappers are first worked, but the natural wear which occurs is almost certain sooner or later, in such a case, to cause this movement to fail altogether, and thus cause a fault.

Over 3,500 single needle instruments are in use in the postal service.

"NEALE'S ACOUSTIC DIAL."

Within the last two years a new form of Single Needle Dial has been introduced with success into some of the single needle instruments used by the Post Office. This arrangement can be read from, either like an ordinary single needle dial, or by means of the ear.

It has often been the practice of highly-skilled clerks to read from the "click" of the needles against the ivory stops, and in many cases the sound has been augmented by attaching barrel pens to the studs, or by home-made devices of a like nature. The object of the Neale dial is to obtain very distinct and decided sounds with the usual current strength employed to work the ordinary form of dial. The way in which this is effected will be seen from figs. 10, 11, 12, and 13; fig. 10 being a front view, fig. 11 a back view, and fig. 12 a side view of this invention. Fig. 13 shows a side view of the needle removed from the frame of the dial.

In these figs. D, D is the ordinary dial plate; to the face of the latter two metal tubes, *t*, *t'*, are secured by means of screws passing through flanges at their end; metal pins, *e*, *e'*, are fixed to these tubes, against which the needle, *n*, *n'*, can strike. The two tubes are made of different thicknesses of metal, so that they emit different notes.

The movements of the needle are effected by the electro-magnet, C, C', the pole pieces, *a*, *b*, of which, project through the front of the dial, as seen by fig. 10.

M is a permanent steel magnet, the lower end of which is bent at right angles to the upper part; this end passes a short distance through the face of the dial, and is in close proximity to the lower end of the upper part, *n*, of the indicating needle. The back part of *n*, fig 13, is formed of a broad piece of soft iron (shown by the shaded portion) through which the axle of the needle passes. This piece of iron becomes magnetised by the inductive action of the permanent magnet, consequently the upper part of *n* is attracted and repelled by the pole pieces, *a*, *b*, in one direction or the other, according to the

direction of the current, and thus the whole needle can be deflected to one side or the other, against the stop pins, $e, e'$.

In order to keep the needle normally in a vertical position, its axis has a small hook, $h$ (figs. 11 and 13), fixed at right angles to it; to this hook, and also to one end of the spiral spring, $g$, a piece of silk thread, $x$, is fastened; the other end of the spring is attached to a screw, $k$, which passes through the piece, $d$, and can be raised or lowered by means of the thumbscrew, $s^2$. By screwing $s^2$ round in one direction or the other it is evident that the tension of the spring, $g$, can be increased or lessened, and consequently the tendency of the needle, $n, n'$, to come back to the vertical position be increased or diminished as required.

The piece, $d$, and with it the thumbscrew, $s^2$, and the screw, $k$, can be moved to the right or left by means of the thumbscrew, $s^1$; by the adjustment of the latter, therefore, any tendency of the needle to hang over to one side or the other from the true vertical position can easily be corrected.

The magnet, M, which has a stop-pin, $p$, is similar in shape and position to the brass piece, A, A (figs. 3 and 4, Art. I.) of the ordinary dial, consequently the whole arrangement can be fitted at once into any of the cases of the complete single needle instruments.

The coils, C, C', are wound to a total resistance of about 200 ohms, and when carefully adjusted the needle can be deflected up to the stops, $e, e'$, if a current of 3·3 milliwebers (see end of Art. I.) traverses the coils, there being sufficient tension given to the spring, $g$, to bring the needle back to zero when the current ceases to flow. For working purposes a current of about 5 milliwebers would be required.

The advantage of the "acoustic" over the ordinary dial is that it leaves the eyes at liberty to see what is being written down on the message-form.

---

ERRATA.—In Art. I., page 23, first column, at the end of the sixth paragraph, *for* "a curved brass spring, *n*, shown in fig. 2," *read* "a curved brass spring, *n*, shown in fig. 1."

On the same page, second column, at the end of the first paragraph, *for* "If the instrument is at a 'Down' station, the terminal A must be put to line and terminal A to earth," *read* "If the instrument is at a 'Down' station, the terminal A must be put to line and terminal B to earth."

On page 25, first column, at the end of the third paragraph, *for* "1 Daniell cell flowing through a total resistance in the circuit of 3,000 ohms, that is to say, a current of $\frac{1}{3000}$ webers, or $\frac{1}{3}$ milliwebers," *read* "10 Daniell cells flowing through a total resistance in the circuit of 3,000 ohms, that is to say, a current of $\frac{10}{3000}$ webers, or 3·3 milliwebers."

---

## A SYSTEM OF ELECTRICAL STORAGE.

IN a paper recently published in the *Journal of the Franklin Institute* Professors Edwin J. Houston and Elihu Thomson have described a system of "Electrical storage" devised by them:—"The various suggestions which have hitherto been made for the storage of electrical energy, in such manner as to readily permit its after recovery in the form of electrical current, have failed when attempted to be carried into practice, either on account of their inherent impracticability, or by reason of the serious inconveniences and losses due chiefly to the following:—

"1st. The extent of conducting surface of the storage apparatus required to be acted on, rendering it cumbrous.

"2nd. The loss of energy due to evolution of gas during the operation of charging.

"3rd. Lack of constancy and duration in the currents evolved after charging.

"4th. The limited capacity for storage due to the proportion of active material being but a fraction of that present.

"The well-known Secondary battery of Planté lacks the requisites of an economical reservoir for electrical action. In the secondary battery the duration of action is chiefly dependent upon the amount of surface of the lead plates employed, and the charge received is necessarily limited on account of the evolution of gas.

"In the system of electrical storage devised, the duration of action and consequent capacity for storage is independent of extent of surface and dependent on the mass of material to be acted upon. In this method a saturated solution of zinc sulphate, enclosed in a suitable vessel, at the bottom of which is placed a plate of copper, to which is connected an insulated conducting wire, are employed. At or near the top of the vessel, and immersed in the solution contained therein, is placed a second copper plate, or plate of hard carbon, or metal unchanged by contact with zinc sulphate solution, and less positive than metallic zinc. This is also connected to a wire. The storage cell so constituted is then ready for charging, which is effected by the passage through the cell of a current, whose direction is from the lower to the upper plate. The current employed is that obtained from a dynamo-electric machine, and the result produced is the deposition of metallic zinc on the upper plate and the formation of a dense solution of copper sulphate overlying the under plate. The duration of the charging action is of course limited only by the amount of zinc sulphate and the thickness of the lower plate. The cell, after charging, constitutes in fact a gravity cell, and continues a source of electrical current until a reconversion of all the copper sulphate into zinc sulphate has been effected, metallic copper being deposited on the lower plate, and the deposit of metallic zinc being removed from the upper. It thus may be allowed to regain its original condition. The re-charging, however, may be effected at any time, either before or after the cell has become inactive. The cell may be covered or sealed to prevent evaporation; and since no addition of new material is needed, a restoration to an active condition is at any time possible.

"A, fig 1, represents a cell of glass, or other suitable material, furnished with two metallic plates, B and C, connected separately by conducting wires to the terminals, *b* and *c*, the wire from the lower plate being insulated. A porous diaphragm, E, is placed before the upper plate, C, to prevent fragments of deposited zinc from falling on the lower plate, which may occur should the charging current be too intense.

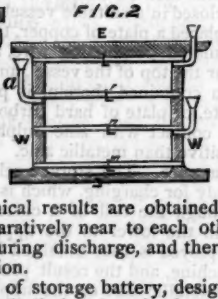
"In charging, the arrangement of the cells in

multiple arc or in series may be adapted to suit the electro-motive force of the dynamo-electric machine employed. The arrangement of the cells in charging may be different from that in discharging, according to the purpose for which the current is designed. Diffusive action of the solutions may be prevented by any of the well-known means used in gravity cells.

"It may be objected that the economical results obtained in the storage of electricity as above-described will necessarily be low, as but a fraction of the electrical energy in charging will be expended in overcoming counter electro-motive force, or in effecting electrolysis, compared with that which overcomes the resistance of the liquid, and therefore lost in heat-production. But this objection is readily met by so connecting the cells as to make their counter action or counter electro-motive force the chief resistance to its passage. Economical results necessarily follow, the economy attained being measured by the relative cost of the fuel required to drive the dynamo-electric machine and that of the zinc and chemicals used for charging a battery of equal power to that of the storage battery used.

FIG. 1

FIG. 2




In charging, economical results are obtained by using the plates comparatively near to each other, and separating them during discharge, and thereby avoiding loss by diffusion.

A convenient form of storage battery, designed for rapid charging and discharging, is shown in fig. 2, where L, L′, L″, L‴ are horizontal plates of copper separated by insulating rings, W, W, the spaces between the plates, L, L′, &c., being filled with a saturated solution of zinc sulphate. Lateral tubes, *a*, are provided to compensate for the expansion of the liquid due to changes of temperature, and also to provide for filling the cells. The cells are held between plates, E E, by bolts which pass from one to the other. In this arrangement, the plates L′ and L″ serve as upper and lower plates, accumulating copper sulphate on their upper surfaces and receiving metallic zinc on their under surfaces. This series may of course be extended. When a number of cells are connected in series, several of them may be charging, while the remainder are used as a source of active current.

The most obvious application of a storage battery furnishing a constant and lasting current, is to replace the ordinary telegraphic batteries. In light-houses, a dynamo-electric machine can be run by suitable power at intervals during the day to furnish an unfailing and reliable source of current for lighting purposes."

Mr. C. F. Varley employed a storage battery to distribute time signals through the telegraph system of Great Britain and Ireland. This battery (which is no longer in use, as Leclanché cells of large dimensions are found to answer the required purpose in a more satisfactory manner) consisted of gutta-percha chambers 4½ inches high, each with a division in the centre 1¼ inches deep; the shallow cells so formed were half filled with mercury, and into these mercury cells carbon plates dipped. The mercury in one cell was metallically connected with the mercury in the contiguous cell of the neighbouring chamber; the last carbons of the set of chambers were connected with terminals, to which the charging and discharging wires were attached. The cells being charged with sulphate of zinc and sulphuric acid, on sending a charging current through the set of cells amalgamated zinc became formed on one carbon in a cell, whilst oxygen formed on the other carbon, and bisulphate of mercury on the mercury in which the latter carbon dipped. Sixty cells of this battery, when charged by 150 small Daniell cells, gave a powerful current, the duration of which depended upon the time the charging battery was kept on. The arrangement having a very low resistance, could give a strong current upon a large number of lines at one time. This, in fact, was the object of the battery.

## CODES AND CODES.

IF any proof were required that human ingenuity has no yet reached its utmost development, it would, we think, be found in the activity existing in the matter of Code making.

After some little contest with the public, first, as to the admissibility of coded messages, and afterwards as to the restrictions that should be imposed upon them, the Telegraph Companies finally recognised the necessity for coding in order to ensure secrecy, and also with a view to promote telegraphing on transactions that would not pay for a large outlay. With a large liberality the length of code words was fixed at seven syllables, as it was expected that code words would fairly alternate with shorter words in plain language. But it was very soon discovered that telegraphers, when code words failed, were accustomed to string together several words or parts of words in one: thus, when short-sightedness had failed to provide for the acknowledgment of a telegram despatched the previous day, such words as "Yestelred" were made up from parts of the words, *Yesterday's telegram received*.

This style of coding was most extensively resorted to by merchants of the lower grade, whose intelligence was not equal to code making. It was however frequently adopted by the larger firms when they found their codes at fault. It was therefore discovered that the words in coded messages, which at the lowest computation might be considered as representing five times the number of words paid for, were as a rule from two to three times the average length of words in plain language messages. Hence the reduction in the number of letters permitted in code words as per St. Petersburgh Convention Rules.

No change was then made in the rating of figure groups, as up to 1875 figures were not largely employed for coding purposes, and groups of two or three figures were as often sent as groups of four or five, but in order to prevent the use of figure cyphers the rule as to the rating of figures was coupled with the proviso that figure groups should be permitted to notify quotations only; but here again it was found that figure groups were as often sent to convey a secret meaning as to express a quotation, and as in the former case they consisted entirely of groups of five figures, the average number of figures per group rapidly approached the maximum number allowed. The Telegraph Companies have decided to remove all temptations to misrepresentation as to the meaning of figure groups by limiting them to three per word and permitting them to have a secret meaning.

This limitation will weigh heavily on a certain class of

telegraphers, and will render the employment of codes necessary even by those that have hitherto confined themselves to plain language messages, inasmuch as such quotations as "6½," "3½," &c., will be reckoned as two words.

Hence the activity in the matter of code making which suggested our opening remark.

We have ourselves ample evidence of this activity, for we have had no less than seven codes sent to us for review, and have heard of several more.

Three of the former have thought fit to accompany their books with the intimation that a handsome douceur would follow a favourable critique. Not caring to air our wounded feelings, and having a very wholesome respect for the law of libel, we simply tell these gentlemen that we deal with facts as we find them. Of the codes sent us we shall speak generally, for we can only describe these codes, with one exception, as traps for telegraphic errors.

One author "begs to assure us that his code words have been telegraphically examined, and that a code which he made for his employers was used without a single telegraphic error that occasioned any inconvenience during the four years it was in use." If this statement be true, it certainly speaks volumes for the correct working of the telegraph companies, for on the first page opened by us we found the code word "Agnatio" followed by the word "Agnatum," and "Agnolen" followed by "Agnolete." Further on we observed the words "Impie" and "Imps," and still further on we found the words "Label," "Labelled," "Labelling," not far from "Libel," "Libelled," "Libelling." We instance these words not as the only examples we found, but because in the three former pairs of words the first sentence represents an affirmative, and the latter a negative.

To us it appears perfectly impossible that the author can have the slightest knowledge of telegraphy, or he would have seen that such words as "Agnatio" and "Agnatum" are far more mischievous than words with only one letter difference, as they are identical in the signals employed, the only difference being in the *spacing*. To employ such code words to represent, the one an affirmative and the other a negative, sentence, we regard as an evidence of the greatest recklessness or ignorance. We lately heard of a code maker who called at an office of one of the principal telegraph companies, and requested to be supplied with a copy of the telegraph signals, naively adding that he had published a telegraphic code, and wished to be able to say that it had been *telegraphically examined*.

As a further proof of the activity existing in the matter of code making, we may state that we have lately heard with surprise that even some of the officials of the telegraph companies are engaged in the work, apparently influenced by the idea that if anything is to be got out of it they may just as well have it as any one else.

Here is a specimen of some words from a list of code words compiled by one of them and his assistants:—"Bird," "Bind," "Bedizen," "Bedewer," "Branding," "Bracing," all of which are different by a dot only, and occur on one page.

There is an old Latin proverb which this official might bear in mind, *Ne sutor ultra crepidam*.

For the public this last freak of telegraph officialism is perhaps a subject for congratulation, for if such words as "Bind" and "Bird" be considered safe words, and exist in the same code, there can be but little excuse if the telegraph companies make mistakes in words where the difference is much greater.

In another code we observed greater difference. Its author had adopted long words. Of fifty words on one page, thirty-seven consisted of ten letters, and eight consisted of nine letters. Of the thirty-seven words, three were Italian words, and ended in "iam," whereas these words, if properly spelt, would have ended in "iamo," and would, therefore, have contained eleven letters. Others ended in "in" instead of "ino," or "ar" instead of "are;" the final letter in each case being dropped for the same reason." We hardly think that after these remarks the authors of these codes will blame us for concealing their names.

Another form of code, or to speak more correctly, another form of code word vocabulary, has lately appeared in the form of "Termination Codes."

The compiler selects a certain number of the most suitable stems of verbs (or "roots," as one author calls them), and then chooses ten or more endings to be attached to each.

Thus 10,000 verb stems, with ten endings for each, will form 100,000 words. The chief advantage of this system is its compendiousness. It is not, we think, free from objections, inasmuch as it restricts the words available for coding purposes to regular verbs only, and ignores the variations to be found in irregular verbs and the other parts of speech. We hardly think that telegraphers would have regarded such a limitation as anything but extremely arbitrary if it had been enforced by the telegraph companies. Irregular verbs appear to us worthy of special *attention*, from the fact that their irregularity often provides the very difference in the words which it is so desirable to obtain. To ignore them may, and doubtless does, largely reduce the labour of selecting a certain number of code words, but it appears to us manifest that a carefully compiled list of code words selected from every part of speech, and every form of verb, and word must, in the main, be safer than a list of words selected on the termination, or *mechanical* principle.

Words with only a letter difference, or worse still, words with similar telegraphic signals, will escape the keenest observation; but it will not fail to be noticed that such weaknesses are generally multiplied in a mechanical code tenfold if the error occur in the stem, or a hundred or perhaps a thousandfold if the error occur in the ending.

Thus in the almost contiguous stems "Accan" and "Accatt," on the first page of one of these codes, the sole difference, besides the spacing, is between a dot and a dash, and as these stems are provided with six endings common to both, the error is multiplied by six.

Again, in the stems "Acafel" and "Acall," apart from the spacing, there is only the difference of a single dot. Yet these stems, though belonging to different languages, have five common endings.

The stems "Atigr" and "Emigr" are perfectly identical so far as signals are concerned, and are provided with one common ending, "ais," whilst another ending in one is "Ames," and for the other, "Amos."

The stems "Arel" and "Arf"—spacing apart—differ but by a single dot, and are provided with eight common endings. The stems "Cisc" and "Trisec" again differ, but by a single dot, and are provided with ten common endings. The same may be said of the stems "Conche" and "Tronch." It is not necessary to pursue this subject farther, but we may add that we have referred to a part only of the weaknesses we observed in a very cursory and hasty examination of the work.

With respect to the kind of stems selected we have little to say, but we cannot but regard the adoption of Italian stems, commencing in "Sb, Sd, Sf, Sg, Sr, and Sv," as open to grave objection. Being strange to the greater number of telegraph operators the initial letter of such words is liable to be detached and appear as the final letter of the preceding word. If an accident of this kind happen to such stems as "Sdebit, Sdent, Sdonn, Sfoll, Sgorg, Svolg," the remaining part of the stem might in some cases, where the endings are similar, and would certainly in other cases where the endings are identical, be mistaken for the stems, "Debett, Dente, Donne, Foli, Gorge, and Volig." In the endings we note that the author makes use of "enclitics;" ten of his sixty Latin endings being compounded of the hort terminations, "o, e, io," &c., with the conjunctions, "que, ne, ve;" and we further note that the author soundly rates a critic who, in reviewing this work in the columns of a contemporary, questions his right to do so, and states that such words as "Abdicoque" are in reality two words.

The author says that he has no doubt about the matter. We can say the same. We have no doubt whatever about the matter, but our opinion is opposed to his, for having enjoyed the benefit of an excellent classical tutor we remember well that we had to parse the conjunction apart from the verb. "What!" he would say, if we omitted to parse the conjunction as well as the verb, "Do you think that word is there for the flies?"

We have accorded to this author a somewhat longer notice than we have given to the others, as we note that the circular, issued to announce the publication of his work, largely consists of no very kindly criticisms on the efforts of others. We have endeavoured to avoid the harsh language in which he so freely indulges. He cannot be ignorant of the difficulties in the way of selecting so large a number of good and safe code words as 100,000. He appears to be conscious

that he has not entirely succeeded in getting a perfect selection in his 50,000, although he had but 5,000 stems to select. At least, we interpret the last paragraph in his introductory remarks to mean this, for he there invites purchasers to leave their names and addresses with the publisher, so that any corrections or improvements may be notified to them, requesting also to be informed of any errors in printing, &c., that may be detected in practice.

For ourselves we believe that it is impossible to exaggerate the difficulties in the way of the successful accomplishment of such a task; and by way of giving point to our remark, rather than with a desire to criticise this author's efforts further, we give one more example before we dismiss the subject. The two stems "Anonn" and "Ponte" are, as to telegraphic signals, perfectly identical, as a n=p and n=te. The stem "Anorte" that follows "Anonn" differs from both as to signals by only a single dot, the first dot of the letter r; but although these words belong to a different language, yet the identity in some of the endings ("ais" being found in both French and Spanish, and "umos" "ando," "aria," "ais," and "o," in Spanish and Portuguese) provides six pairs of words, in one of which no difference whatever exists in the signals, and in the other five the difference is only a single dot.

We hope to offer some remarks on "Codes and Coding" in an early issue.

## Notes.

An accident of an extraordinary nature occurred recently at the Holte Theatre, Aston, near Birmingham. The stage was lighted by two electric lights, and when the candles were not burning two brass connections used for the purpose of crossing the current were hung up over the orchestra. After the performance of the pantomime Mr. Bruno, the euphonium player, was leaving with the other members of the band, when, presumably out of curiosity, he caught hold of the two brass connections referred to. The man in charge called out to him, with the object of warning him of the danger he was incurring. The caution, however, came too late. Mr. Bruno received the full shock of the electric current, generated by the powerful battery which supplies the whole of the lamps in the building and grounds. The shock rendered him insensible. A medical man was at once sent for and restoratives were applied, but Mr. Bruno died in about 40 minutes afterwards. If the connecting wires had been insulated in the usual way it is evident that the accident would not have occurred.

M. W. de Fonvielle writes to a contemporary that: "M. Denayrouze, the former lessee of the Jablochkoff candle, has purchased the Jamin candle, in which the electric flame is directed by the attractive power of magnetism or electricity. Private experiments have been made, and they are preparing for an exhibition in one of the suburbs of Paris. M. Jamin having to lecture at the Sorbonne on January 17th it is probable that the large hall will be illuminated by his own light on this occasion. This light company has purchased a patent for gas engines, and will try to use the gas under the furnace as fuel, dispensing with it for illumination. They are said to contemplate a public issue of shares for a large capital." Also, he says, the Messrs. Siemens' agents "are at present fitting a large factory at Meaux with their regulators and generators."

Mr. Dalman of Barcelona (Spain), well known as the introducer of electric light in that country, has just established a light in his show room, at some distance from his works. A conductor 560 metres in length connects the lamp to the Gramme machine. Only one conductor is used, as the earth is used instead of a return wire. This, we believe, is the first instance of the electric light being used at such a distance from the generator with only one conductor. In London it is contemplated to use the rails of the permanent way on the Metropolitan Railway in the place of a return wire, when the contemplated extension of the Jablochkoff system, already in existence, is carried out.

The reports of the success of Edison's new electric light at his Menlo Park laboratory have had the effect of advancing considerably the price of shares in the Edison Electric Light Company. The total capital stock of the company is 300,000 dols., in 3,000 shares at 100 dols. each, and the company controls the right for the entire United States. Within ten days the shares were quoted at 1,000 dols. each; the next recorded sales were one share for 2,500 dols.; two shares sold for 3,300 dols., and another share for 3,500 dols. Holders of the stock are now asking 5,000 per share. —*Railway News.*

On Wednesday, the 7th of January, for the first time, except for the sake of experiment, six Jablochkoff electric lights were used around the stately mansion of the Marquis of Salisbury, at Hatfield, the occasion being a grand ball. The effect is described as simply marvellous, the whole vicinity of the mansion being lighted up as if by daylight.

Mr. David Flannery, an assistant superintendent of the Western Union Telegraph Company in Mississippi, has recently discovered a new method of dividing the electric current for illuminating purposes. His claims have all been allowed and recognised in the Patent Office at Washington.

The German Telegraph Engineers have reported favourably on the alloy of alminium and iron; it produces a wire both finer and stronger than iron wire, less susceptible to atmospheric changes, and superior as a conducting medium.

The Merchants' Telephone Exchange in New York has upwards of 600 wires entering its central station. The Edison telephone is used, and more than 1,000 battery cells are required for working the same.

The telephone is now used on the South Eastern Railway to facilitate conversation between the station-masters at Charing Cross and Cannon Street stations. Gower's improved Bell is the instrument mentioned.

Gower's Telephone.—A company has commenced operations at Gresham House, Old Broad-street, to work the Gower patent telephone, using it in conjunction with a carbon transmitter. All kinds of telephonic business are undertaken by this company, except that on the exchange or central system.

Crossley's patent microphonic telephone transmitter seems to be used extensively and with great success. Amongst other places we may mention that the Lancashire and Yorkshire Railway Signal Cabins are fitted with it, and also the depots of the Leeds Tramways Company. The Post Office authorities have adopted this form of telephone for use in connection with their private wire system.

The Post Office and the Telephone.—On January 20, in the High Court of Justice, before the Lord Chief Baron and Mr. Justice Lopes, an infor-

mation filed in the Exchequer Division by the Attorney General against the "Telephone Company" for a breach of the Post Office Telegraph Act was mentioned:—The Attorney-General said he wished to mention this case, but not to make a motion in it. He had filed an information against the company with the view of restraining them from using certain wires, which the Postmaster-General said were telegraph wires, and of which that Minister had a monopoly, which he had purchased at an enormous sum. He had been instructed to move for an interim injunction against the company, but he was happy to say they had made the following arrangement. The company had agreed with the Postmaster-General to the effect that the motion in the case should be postponed until a day subsequently to be appointed for the hearing. Affidavits in reply were to be furnished by the company on or before January 27, and the Postmaster-General would have 10 days to reply to them. The case would then be brought on as soon as their lordships would be able to fix a day. The information had been filed in the Exchequer Division. In the meantime the company had agreed to keep an account of the number of telegraph messages they sent out and the earnings they made.

Mr. Macrory represented the company, but was not present, as he understood the arrangement had been agreed to.

Their lordships granted the application for the postponement of the motion accordingly.

In the same court an information against the "Edison Telephone Company" was also mentioned:—The Attorney-General said he was instructed in this case, with Mr. Kay, Q.C., Mr. Simpson and Mr. Karslake, to move their lordships for an interim injunction to restrain the company from carrying on their business in telegraphy. An information had been filed by him in this court, supported by affidavits by the Postmaster-General. From those affidavits it appeared that the company used the telegraph wire for sending messages throughout London for the purposes of reward, and the Postmaster-General said they were telegraph wires within the meaning of the Acts of 1863, 1868, and 1869, and that the use of them by means of the telephone was an infringement of the statute. He asked for an interim injunction to last until the hearing of the cause, but he would be quite ready, with the consent of his learned friend who appeared on behalf of the company, that the same arrangement should be made in the present as had been agreed to in the former case.

Mr. Cozens Hardy, on behalf of the company, said his clients were very anxious that the motion should be disposed of as soon as possible. His affidavits would be filed by Thursday next, when the motion could be disposed of.

The Lord Chief Baron inquired of the Attorney-General whether he asked that the motion should be considered now or that the motion should be postponed?

The Attorney-General replied that he would be quite willing that the latter course should be adopted if, in the meantime, the company would keep an account of the messages sent by their wires. The Postmaster-General wished to reply to the affidavits which would be filed by the company.

Mr. Cozens Hardy said his clients were quite ready to keep an account of their receipts and expenditure, but he was instructed that they had no means of keeping such an account as the Attorney-General had mentioned.

The Attorney-General said the account required was of the following nature. Supposing a person in Brompton wished to send a message to a person in Broad-street by means of the telephone, the former would request the authorities at the central office to connect him with the office at Broad-street. The connection was made, and the two persons carried on a conversation as long as they liked. All that was required was that an account should be kept of the number of times a connection was made.

Mr. Cozens Hardy said his clients instructed him they had no means of doing so.

The Lord Chief Baron said it must be possible to keep such an account without the slightest difficulty. It was to the advantage of the company to accede to the application. The Attorney-General had a perfect right at any time to come into court and obtain the postponement of a motion whether it was opposed or not.

Mr. Cozens Hardy then agreed to speak with the Attorney-General and arrange with him for the motion to stand over upon the conditions mentioned.

The motion was postponed accordingly.

In a recent paper to the Vienna Academy, by Prof. Exner, on the theory of inconstant galvanic elements, proof is offered that there is no so-called galvanic polarisation in elements, but that the phenomena referred thereto are attributable to the oxygen dissolved in water. The electromotive force of an element with only one liquid appears accordingly as a constant which is in no way affected by any polarisation of the negative pole. It is further shown that the force of a Smee element is not altered when its platinum is replaced by some other metal, provided only this do not itself give rise to chemical processes.

The German Postmaster-General, Herr Stephan, and Dr. Siemens, have succeeded in constituting an electro-technical society, which has for its objects the furtherance and development of the technical application of electricity, the progress of the knowledge of electricity by means of its technical appliances, and the establishment of a place of meeting for German technical electricians, whose scientific and commercial interests will, of course, be greatly benefited by such mutual intercourse.

*Iron* of January 23rd, in speaking of the Post Office and the telephone companies, says:—"The Telephone Company, *which does not employ electricity at all in transmitting its messages*, ought at least to occupy safe ground." [The italics are ours.—ED. T. J.]

MAC MAHON TELEGRAPHIC NEWS CO. (LIMITED).—This company has been registered with a capital of £25,000, in shares of £10, and to adopt and carry into effect an agreement, and is to erect and work between any office, residential club, place of business, &c., wires and apparatus for transmitting news. The subscribers (who take one share each) are:—T. E. Mac Mahon, Shepherd's Bush; J. Peacock, Hammersmith; J. B. Amor, Circus-road; L. Lumley, 20, Montague-place; R. K. Clay, Dublin; S. Sharpe, 12, Devonshire-place, and T. Sharpe, 41, St. James's-street.

IRON AND STEEL WIRE.—Messrs. T. and L. Jenkins announce that their prices for all kinds of iron and steel wires are again advanced 1s. 6d. per cwt., or 10d. per bundle, upon price list dated October 25th, 1879.

BALMAIN'S LUMINOUS PAINT.—*Engineering* says: "The Lords of the Admiralty have been making experiments with it in a darkened room at Whitehall, and have expressed themselves in favour of it for lighting

up the compartments of ironclads, or for the powder magazines; and two compartments of H.M.S. *Comus* have been ordered to be painted with it. For life-belts and buoys, it will of course be an acquisition in rendering them visible by night. A lantern capable of enabling a person to read or work in the dark can be made by framing a few square feet of painted surface; and the superintendent of the West India Docks has ordered lanterns for use in their dangerous spirit vaults. The virtues of these lanterns in explosive mines, petroleum stores, and cellars, are too obvious to be dwelt upon. Mr. Towers, who has just supplied the German Navy with his speed indicators, and is now engaged in adapting them also to several English war vessels, notably H.M.S. *Northampton*, has decided to have the dials of his apparatus illuminated in this way so as to enable seamen on the darkest night to read the index. Mr. Hollingshead, the enterprising manager of the Gaiety Theatre, is in treaty to secure the sole right to apply the paint in the production of theatrical effects; and it is probable that the process will soon come into conspicuous use as a medium for advertisements.

## Proceedings of Societies.

### PHYSICAL SOCIETY.—JANUARY 24TH, 1880.

Prof. W. G. ADAMS in the chair.

New Member.—Mr. W. ELLIS.

Mr. GRANT read a paper and exhibited experiments on "Induction in Telephonic Circuits." He was led to these experiments by a former observation. When an induction coil primary was placed in a circuit consisting of a telephone, microphone, and battery, the microphonic sounds heard in the telephone were increased on closing the secondary circuits of the coil. Employing a double wound coil—that is, one having primary and secondary side by side—he found that the latter could act as a condenser, and "relay" or translate messages into a second circuit, the microphone and battery being in the circuit of one wire (*i.e.*, the primary and the other wire or secondary containing a telephone). He also inserted a double wound coil in the latter or secondary circuit, and caused the induced or translated current to flow through both the wires of this double coil one after the other, in the same direction. The effect was weak; but on reversing the current in one half of the double coil, by means of a commutator, so as to make it double on itself, as it were, the weakening effect of induction was neutralised and the sounds heard were as loud as if no coil had been inserted in the secondary circuit at all, as was proved by short-circuiting the double coil altogether.

Dr. O. J. LODGE read a paper on "Intermittent Currents and the Theory of the Induction Balance." The telephone, as a scientific instrument, seems destined to play an important part as a detector of minute currents of rapidly changing intensity, and the general theory of intermittent currents is being brought into prominence by its use. The equations to which most attention has been hitherto directed have been those relating to the steady flow of a current after the initial inductive or inertia-like effects have subsided. The galvanometer is essentially an instrument for measuring steady currents or for giving the algebraically integrated expression for the total quantity of electricity which has passed in the case of transient currents. But the telephone plate has a very small period of swing compared to a needle, and, moreover, the plate is not limited to one mode of vibration like the needle. The induction balance was used experimentally by Dove and Felici, but was not appreciated as an instrument of research till Prof. Hughes applied to it the telephone and an intermittent current.

The general theory of the establishment of a current in circuits of known resistance was given by Thomson, and is to be found in Maxwell's "Electricity." Dr. Lodge used this theory in order to work out the theory of the Induction Balance, and one or two other cases of intermittent current, as completely as possible, without taking into account the electrostatic capacity of the wires, and leakage. The current in either primary of the balance is the same, and the current in either secondary is the same at every instant of time; in fact, the separating of the two balances of the circuits is immaterial to the theory. The current induced in the secondary circuit is a tertiary current induced from the third piece of conducting matter inserted between the primary and secondary. An expression being got for the strength of current in the telephone at any instant after a change in the resistance of the primary has occurred, the author deduces among other things the law according to which a small coin by its position and size, disturbs the balance. Dr. Lodge remarked that Prof. Hughes either by inventive intuition or great pains, had hit upon the best form of the apparatus for his purpose. The paper, which is very complete, is to be published in the *Philosophical Magazine* for February.

HERR FABER then exhibited his new speaking machine, which is designed to imitate mechanically the utterances of the human voice by means of artificial organs of articulation made on the human model, and actuated by an operator who depresses certain keys as in playing a musical instrument. The organs are a bellows made of wood and india-rubber, which answers to the lungs; a small windmill placed in front of the latter to give the "r" or trilling sounds; a larynx made of a single membrane of hippopotamus-hide and india-rubber to give the "drone" or basic tone of the voice; a mouth with two lips, a tongue, and a nose or proboscis made of india-rubber tubing placed below the mouth but curving up towards it. Fourteen distinct vocal sounds can be uttered by the instrument; but in combining these every word in any language can be played by the keys. Thus Herr Faber caused his machine to say such words as "Mariana," "Eliza," "Philadelphia," "Constantinople," and various sentences in French, English, and German, more or less distinctly. Laughing and whispering were also produced, and the voice of the instrument which was ordinarily loud and clear, and resembling that of a girl, was lowered in pitch and loudness to a more masculine tone.

### SOCIETY OF TELEGRAPH ENGINEERS.

THE opening meeting of this society for the present year was held on Wednesday the 28th ult.

The chair, at the opening of the meeting, was taken by Lt.-Col. BATEMAN-CHAMPAIN, R.E.

The minutes of the previous meeting having been read and confirmed, Lt.-Col. CHAMPAIN introduced the new President, Mr. W. H. PREECE. A vote of thanks having been proposed to the retiring president by Professor ABEL, F.R.S., and seconded by Sir CHARLES BRIGHT, Mr. PREECE took the chair and read his inaugural address—a full report of which is given elsewhere in this Journal.

At the conclusion of the address a vote of thanks was proposed to Mr. PREECE by Mr. LATIMER-CLARK and seconded by Mr. C. E. SPAGNOLETTI. A ballot for proposed new members having then been taken, the meeting adjourned till February 11th.

# City Notes.

Old Broad Street, Jan. 29th, 1880.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—An extraordinary general meeting of this company was held on Thursday, the 22nd ult., at the City Terminus Hotel, Cannon Street, Sir EDWIN WATKIN, M.P., presiding, for the purpose of varying the borrowing powers conferred by an extraordinary meeting in December last, and authorising (in addition to the borrowing powers conferred on the directors to the extent of £250,000) the creation and issue of debentures to the further amount of not exceeding £250,000. The Chairman said he explained at some length to the last meeting the reasons why the plan of redemption from their difficulties which he had proposed should be varied in deference to what was looked upon by many as a better one. He then told them that the question of the adoption of the better plan had been settled in principle, and that there was no reason to expect it would break down in detail. That detail was referred to Mr. Mendel, the deputy-chairman, Mr. Cooke, and the members of the Finance Committee, who had been devoting themselves to the settlement of the question, and now reported that they expected payments on account within a very few days. They might therefore consider the matter settled, subject to the passing of the necessary resolution as follows, which he proposed: "That the borrowing powers conferred by the extraordinary general meeting, held on December 22nd, 1879, be varied, and that in addition to the sum of £250,000, which the directors are empowered to borrow under the 17th article of association, the directors be authorised to create and issue debentures to the further amount of £250,000, for the purpose of providing for the redemption of the whole or any portion of the 'A,' 'B,' or 'C' debentures of the Company, and for the general purposes of the Company;" that really meant giving them power to borrow £500,000 instead of £250,000. This would enable them to meet the debentures coming due, pay off their debts, repair the cable, and leave a margin of £50,000. Mr. MENDEL seconded the resolution. In reply to a shareholder, the Chairman said that there were £303,000 of debentures of all kinds falling due in August next, their debts amounted to about £50,000 or £55,000, they wanted £40,000 to provide a new cable, and the "C" Debentures not yet drawn would take another £50,000. That made in round numbers £450,000, and the remaining £50,000 would remain as a margin to meet any future contingencies. The motion was then put to the meeting, and passed unanimously, and a vote of thanks to the chairman closed the proceedings.

EASTERN TELEGRAPH COMPANY (LIMITED).—The fifteenth half-yearly ordinary general meeting of the shareholders in this Company was held on the 22nd ult., at the City Terminus Hotel, Cannon Street, under the presidency of Mr. JOHN PENDER, M.P. The report of the directors for the six months ended 30th September last stated, *inter alia*, that the Company's revenue for that period amounted to £229,095 5s. 8d., from which was deducted £60,538 3s. 1d. for the ordinary expenses of the Company and £19,140 11s. 8d. for special expenditure during the half-year, which, with £3,112 16s. 11d. for income-tax, left a balance of £146,303 14s. From this amount, £38,599 5s. 5d., the interest on debentures and the dividend on the Six per Cent. Preference Shares to the 30th September, together with two interim dividends on the ordinary shares for the quarters ending 30th June and 30th September, 1879, amounting together to £131,024 5s. 5d., had been paid, leaving a balance of £15,279 8s. 7d. to be carried forward. The several sections of the Company's cables continue in good working order. The Chairman, before moving the adoption of the report, amongst other remarks, said: "I think, if you will indulge me for a time, that this is an occasion on which we may fairly review a little the position of this Eastern Telegraph Company (hear, hear). The South African cable has just been completed, and it is an event on which I think we may all congratulate ourselves. It is only six months ago, at our general meeting last July, that I brought the question before you, and got your approval to certain resolutions which I then placed before you in order to enable us to take part in that important work. To-day we have to congratulate ourselves on its completion, and, as I have said, I think I may now review a little the past history of this Company, so that the shareholders may fully understand the valuable property which they possess. A glance at the map of our system will show that we have triplicate cables to Malta and Egypt, and duplicate cables to Spain, Portugal, Gibraltar, Aden, and India. From Aden the cable is continued to South Africa, and from India the lines of the Eastern Extension Company bring us into connection with the Straits Settlements, Cochin China, Japan, Java, Australia, and New Zealand. We have also a network of cables in the Mediterranean running from Greece to Tenedos, on to Salonica, and through the Bosphorous to Constantinople, with a cable in the Black Sea to Odessa, and another from Alexandria to Cyprus—indeed, nearly every place of importance in the Levant is connected with one of this Company's cables. The whole mileage and capital is as follows:—The Eastern Company has now a total of 16,331 miles, and a total capital of £5,279,000; the Eastern Extension Company has 9,928 miles, and a capital of £2,957,000; and the South African Company has 3,925 miles, and a capital of £950,000. That makes a gross total of 30,184 miles of submarine cable, and £9,186,500 of capital. The important link now completed, which connects the South African Colonies with our system at Aden—a mileage of about 3,925 miles, and which is to be, for financial reasons, worked under the title of the Eastern and South African Telegraph Company—is the most important connection for length, and, so far as we can now judge, also likely to be for profit. It will be in the recollection of many of the shareholders that the Eastern Telegraph Company as now constituted was formed in 1872 by the amalgamation of the following companies:—The Anglo-Mediterranean, Falmouth, British Indian, and the Marseilles. I may mention that I am giving you this information to-day because there is an impression abroad that our system has been very seriously 'watered,' but I think I shall be able to show you by figures that we stand in a thoroughly respectable position as regards that question. Well, then, to place the shareholders in these separate undertakings on an equality—for at that time there was a great clamour for amalgamation—a certain number of bonus shares was allotted. The amount of these bonus shares was £957,000, or about 18 per cent. of our gross capital of £5,279,000. Thus the original shareholders, as pioneers of the enterprise, obtained a certain advantage over those buying later, and they are to-day earning about 7½ per cent. We are paying a dividend of 5 per cent., but those who joined the Company at the beginning are actually receiving 7½ per cent. on their money. But inasmuch as our shares stood for a long period at a discount of 30 to 40 per cent., which price gives a return of about 7½ per cent., a very large proportion of what I would call our later shareholders are in as good, if not rather a better position, than the original pioneers of the Company. The present price of our shares is about

10 per cent. discount, showing that the public begin to realise the improving nature of our property. For some years our traffic has been practically stationary. I have had to tell you at meeting after meeting that this arose in a great degree from the depression of trade which has visited not only our own country, but which has prevailed over every part of the world. I have also said that there was no better barometer of trade than the telegraph system, and I am glad to state to you to-day, as you all know, that trade is reviving not only here, but in every part of the globe, and that we are now beginning to rise considerably in the scale of improved and increased traffics (hear, hear). I may say this—that whereas twelve months ago we were probably earning about 6½ per cent., I believe that this last week we have earned nearly 11½ per cent. Another point I wish to bring before you is this. We have completed this South African system—the Eastern Telegraph Company, and the Telegraph Construction and Maintenance Company have literally completed the whole of that important work. We, the Eastern Company, hold £200,000 of shares in the South African Company; we shall hold them to all time, and we shall hold them because we believe from what we see that this will be a very important and valuable feeder to the Eastern Company's resources. We have also the advantage from this connection in having a considerable increase in traffic over our line from the African system. We had also to take as our portion £200,000 of debentures. We have offered those debentures before the cable was completed to our shareholders. They have not all been taken up. A considerable portion—something like £300,000—has been taken up out of £600,000, and the balance is held by the Telegraph Construction Company and ourselves. Such is the improved prospect at the present moment, for the cable gives such satisfactory results that we have got the Telegraph Construction Company to give us the call of those debentures for a very short period, so that we may offer them to our Eastern Company shareholders. I therefore intend to send a circular to our shareholders offering them *pro rata* these debentures."

DIRECT UNITED STATES CABLE COMPANY.—The Board of this Company have resolved upon the payment of an interim dividend of five shillings per share, being at the rate of five per cent. per annum for the quarter ending 31st December, 1879, such dividend to be payable on and after the 16th February, 1880.

THE EASTERN EXTENSION TELEGRAPH COMPANY (LIMITED) notify that the interest due on their Six per Cent. Debentures will be paid on and after the 1st of February at the Consolidated Bank.

LA COMPAGNIE FRANÇAISE DU TÉLÉGRAPHE DE PARIS À NEW YORK.—This Company's cable is now open between France and America. Messages intended for that route must bear the indication "*via* P. Q." This instruction will be transmitted free.

OWING to the opening of the cable communication just mentioned, the Anglo-American Company from February 1st reduce their tariff on continental messages (only) to and from America to 6d. per word; the other tariffs remain for the pr esent as before.

The following are the final quotations of telegraphs for January 28th:—Anglo-American, Limited, 60-61; Ditto, Preferred, 85¼-86¼; Ditto, Deferred, 35-36; Brazilian Submarine, Limited, 7¾-8; Cuba, Limited, 8¾-9¼; Cuba, Limited, 10 per cent. Preference, 16½-17; Direct Spanish, Limited, 1¾-2¼; Direct Spanish, 10 per cent. Preference, 11-11½; Direct United States Cable, Limited, 1877, 10¾-11½; Eastern, Limited, 8¾-9; Eastern 6 per cent. Preference, 11¾-12¼; Eastern, 6 per cent. Debentures, repayable Oct., 1883, 103-106; Eastern 5 per cent. Debentures repayable Aug., 1878, 102-105; Eastern, 5 per cent., repayable Aug., 1899, 101-103; Eastern Extension, Australasian and China, Limited, 8¾-9; Eastern Extension, 6 per cent. Debenture, repayable February, 1891, 107-110; 5 per cent. Australian Gov. Subsidy Deb. Scrip, 1900, 100-102; Ditto, registered, repayable 1900, 101-103; German Union Telegraph and Trust, 8¼-9; Globe Telegraph and Trust, Limited, 5¾-5¾; Globe, 6 per cent. Preference, 11¼-11½; Great Northern, 9-9¼; Indo-European, Limited, 23-24; Mediterranean Extension, Limited, 3-3½; Mediterranean Extension, 8 per cent. Preference, 10½-11; Reuter's Limited, 10-11; Submarine, 230-240; Submarine Scrip, 2¼-2⅜; West Coast of America, Limited, 1¼-1⅝; West India and Panama, Limited, 1⅝-1¾; Ditto, 6 per cent. First Preference, 7¼-8; Ditto, ditto, Second Preference, 6¾-7¼; Western and Brazilian, Limited, 6¼-6¾; Ditto, 6 per cent. Debentures "A," 100-103, Ditto, ditto, ditto, "B," 99-103; Western Union of U.S. 7 per cent., 1 Mortgage (Building) Bonds, 120-125; Ditto, 6 per cent. Sterling Bonds, 105-107; Telegraph Construction and Maintenance, Limited, 35-36; Ditto, 6 per cent. Bonds, 103-105; Ditto, Second Bonus Trust Certificates, 2⅞-3⅛; India Rubber Co., 13¾-14¼; Ditto, 6 per cent. Debenture, 106-108.

## TRAFFIC RECEIPTS.

| Name of Co., with amount of issued capital, exclusive of preference and debenture stocks. | Anglo-American Co. £1,000,000. | Brazilian Sub. Co. £1,300,000. | Cuba Sub. Co. £160,000. | Direct Spanish Co. £116,379. | Direct U.S. Co. £1,213,900. | Eastern Co. £3,697,000. | Eastern Ex. Co. £1,997,500. | Gt. Northern Co. £1,500,000. | Indo-Euro. Co. £425,000. | Submarine Co. £338,225. | West Coast America Co. £300,000. | Western and Brazilian Co. £1,398,200 | West India Co. £883,810. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | £ | £ *a* | £ | £ | £ | £ | £ | £ | £ | £ | £ | £ *a* | £ |
| Dec., 1879 ... | 59,010 | 12,524 | 3,000 | 1,551 | 19,670 | 45,704 | 26,025 | 16,936 | ... ... | * | * | 10,747 | 4,834 |
| Dec., 1878 ... ... | 47,040 | 14,231 | 3,095 | 940 | 13,970 | 38,467 | 22,929 | 14,803 | ... ... | 8,498 | ... ... | ... ... | 5,442 |
| Increase ... ... | 11,970 | ... ... | ... ... | 611 | 5,700 | 7,237 | 3,096 | 2,133 | ... ... | ... ... | ... ... | ... ... | ... ... |
| Decrease ... ... | ... ... | 1,707 | 95 | ... ... | ... ... | ... ... | ... ... | ... ... | ... ... | ... ... | ... ... | ... ... | 608 |

*a* Four weeks. * Not yet published.